

# Refactoring Learning Management Systems for Multi-Device Use in Developing Countries

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## **DEDICATION**

*Dedicated to me and my family – the Ssekakubo Family*

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In the name of God: The most Gracious; the most Merciful.

First of all, I would like to thank God, the Almighty Allah for his mercy upon me, my family and my friends, and that it is in his true guidance that I have found this success.

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## LIST OF PUBLICATIONS

1. Ssekakubo, G. Suleman, H. and Marsden, G. 2014. *A Streamlined Mobile User-Interface for Improved Access to LMS Services*. In Proceedings of the Sixth International Conference on Mobile, Hybrid, and On-line Learning eLmL 2014, Barcelona, Spain, March 23 - 27, pp. 92 – 101, IARIA.
2. Ssekakubo, G. Suleman, H. and Marsden, G. 2013. *Designing Mobile LMS Interfaces: Learners' Expectations and Experiences*. Interactive Technology and Smart Education Journal, Vol. 10, Issue 2, pp. 147-167.
3. Ssekakubo, G. Suleman, H. and Marsden, G. 2012. *Learning Management Systems: Understanding the Expectations of Learners in Developing Countries*. In Proceedings of the IADIS International Conference, e-Learning 2012, Lisbon, Portugal, July 17–23 2012, pp. 251-260. (Won Best Research Paper Award. <http://iadisportal.org/elearning2012>).
4. Ssekakubo, G. Suleman, H. and Marsden, G. 2011. *Issues of Adoption: Have E-Learning Management Systems Fulfilled their Potential in Developing Countries?* In Proceedings of Annual Conference of the South African Institute for Computer Scientists and Information Technologists (SAICSIT) 2011, Cape Town, South Africa, 3-5 October 2011, pp. 231-238, ACM.

## **ABSTRACT**

Although learning management systems (LMSs) have been widely adopted by universities in developing countries, their potential to support students' learning has not been fully exploited due to several factors. Some of the factors limiting the more successful implementation of LMSs in developing country universities have been identified and reported in this study. Most importantly, LMS implementation in developing country universities is constrained by limited institutional ICT infrastructures, Internet bandwidth and electricity outages that affect the accessibility of LMS services by the students.

The main research question addressed in this study is: How can we better use the available ICTs and ICT infrastructure in developing country universities to enhance the accessibility of the LMS services by students to better support the implementation of LMSs?

The research question was addressed through surveys and experimentation. Two surveys were carried out, and the findings of these surveys were useful in: understanding the current state of practice in LMS implementation in developing country universities; defining the problem; understanding the students' LMS expectations and needs; and deciding the nature of the intervention to be implemented. Through the surveys, it was established that the majority of students in the surveyed universities possessed mobile phones, most of which being internet enabled phones. The study therefore explored the possibility of enabling and enhancing mobile access for LMS services so as to enhance students' LMS accessibility through their mobile phones.

The design, development, implementation and evaluation of the intervention (the mobile LMS) were achieved through a user-centred development approach that included participatory design, prototyping and user experience evaluation.

An impact evaluation of the mobile LMS intervention indicated that: mobile LMS interfaces can lead to students' increased access and use of the LMS through mobile phones; students prefer streamlined mobile LMS interfaces with fewer and block-based services; with streamlined mobile LMS interfaces, students are able to get the LMS services they need on their mobile phones without the need for desktop and laptop computers and without the need for the full desktop LMS interfaces.

While the streamlined mobile LMS allows the students an opportunity to more satisfactorily access the LMS services through their mobile phones, it also takes away the pressure from the constrained institutional ICT infrastructure and facilities such as computer laboratories.

The design and development process of the mobile LMS intervention highlighted that students' involvement leads to creation of more usable and useful mobile LMS interfaces and that most of the students' mobile LMS needs can be achieved through a cross-platform mobile Web application.

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

As universities in developing countries strive to satisfy their students' needs, they are facing various challenges and competition at different levels, ranging from local to global. Some challenges may require that the universities have to identify and adopt new mechanisms of interacting with their students. As Barone (2005) and Krause (2007) argue, in a globally-competitive educational system, innovative universities that promote a culture of change and are willing to adopt new technologies for enhancing the students' learning experiences stand a better chance of staying relevant and thriving in the new knowledge age. Information and communication technology (ICT) has proved to be an essential component of the educational system. It has positively impacted the educational system and has played an important role in meeting challenges ranging from educational and administrative through to supportive (Akour, 2009).

The application of ICT to support (or enhance) teaching and learning is commonly referred to as electronic learning or simply e-learning. E-learning covers a spectrum of activities from supported learning to blended learning to learning that is delivered entirely online. According to Kakasevski *et al.* (2009) and Akeroyd (2005), among the various ICT tools that can be used to implement e-learning, Learning Management Systems (LMSs) are the most widely used tools for the support of blended learning and learning that is entirely delivered online. In fact, according to Paulsen (2003), much of the success of e-learning can be attributed to the availability of LMSs. Paulsen (2003) further stresses that the majority of European institutions have extensively implemented and benefited from e-learning via LMSs, a fact that is also affirmed by Masutu (2012). In developing countries, however, although institutions have increasingly adopted and deployed LMSs, the potential of the LMSs to support e-learning has not been fully exploited due to poor ICT infrastructure, among other constraints. In this study, the constraints that limit the more successful implementation of the LMSs in developing country universities were investigated and an intervention to reduce the impact of some of the identified limiting factors was designed, developed, implemented and evaluated.

### 1.1.1 Defining the LMS and Related Terms

In their article entitled “*An argument for clarity: What are learning management systems, what are they not, and what should they become*”, Watson *et al.* (2007) argue that greater attention is needed in using non-standardized terms describing the application of computers to education, particularly with regard to LMSs. They present a definition of an LMS as a systemic infrastructure that manages the learning process of an entire organization or institution and contrasts LMSs with related but conceptually different terms often confused with LMS, such as: Course Management Systems (CMSs) and Learning Content Management Systems (LCMSs). According to Watson *et al.* (2007), the key to understanding the difference between LMS and the related terms (LCMS and CMS) is to understand the systemic nature of an LMS, which represents the LMS as an infrastructure that delivers and manages instructional content, identifies and assesses individual and organizational learning or training goals, tracks the progress towards meeting those goals, and collects and presents data for supervising the learning process of an institution as a whole. The systemic nature of an LMS was first defined by Szabo and Flesher (2002).

On the contrary, CMSs are used primarily for supporting the placement of course materials online, associating students with courses, tracking student performance, storing student submissions, and mediating communication among the students and instructors. Watson *et al.* (2007) argue that although some of the same functionality of the CMS can be seen within LMSs as well, the systemic nature of an LMS does not limit its functionality to that of a CMS. Therefore, while a CMS could be seen as a part of an LMS, it is certainly not equivalent to an LMS. The technologies were developed for very different reasons even if they share certain functionalities (Carliner, 2005). Furthermore, Watson *et al.* (2007) and Carliner (2005) mention Blackboard<sup>1</sup>, WebCT<sup>2</sup>, Sakai<sup>3</sup> and Moodle<sup>4</sup> as examples of CMSs, which is a good example of the confusion that exists regarding these terms, as these (Blackboard, WebCT, Sakai and Moodle) are commonly referred to as LMSs in most literature and by the user community.

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<sup>1</sup><http://www.blackboard.com>

<sup>2</sup>[www.webct.com](http://www.webct.com)

<sup>3</sup><http://www.sakaiproject.org>

<sup>4</sup><http://www.Moodle.org>



Because they were initially designed for different environments – CMSs for academic environments and LMSs for workplace learning environments – the two systems have several distinct differences (Carliner, 2005). However, the user community, especially academic institutions using CMSs such as Blackboard, WebCT, Sakai, and Moodle, refer to them as LMSs. And therefore, this study uses the term LMS instead of CMS to mean such systems as Blackboard, WebCT, Sakai and Moodle.

LMS is also often used interchangeably with LCMS, yet, in reality, the two applications focus on different functions. As Oakes (2002) reports, the key difference between the two technologies is that an LCMS is used to create, store, assemble and deliver personalized e-learning content. That is, the focus with LCMS is ‘content’ as it tackles the challenges of creating, reusing, managing and delivering the content. However, the LMS is learner and organization focused, meaning that it is concerned with the logistics of managing learners, learning activities and the competency mapping of an organization or institution (Oakes, 2002). According to Oakes (2002), LCMSs and LMSs are distinct in focus but complementary, and together they form a powerful combination for a robust e-learning platform. However, he also asserts that the integration between an LCMS and an LMS should not be taken for granted, and that for the combined solution to be successful, they ought to interoperate effectively in at least two key areas:

- i. Personalized delivery: Though the delivery aspects are an integral part of the LCMS, often the LMS is the system that maintains most of the user information needed to personalize delivery, such as user profile, background, job functions and preferences. The mechanism of how the LCMS obtains that information from the LMS in real time to offer successful personalized delivery is another important consideration for the smooth functioning of the combined systems (Oakes’2002).
- ii. Tracking: Typically, an LCMS is much closer to the content than an LMS. An LCMS has intimate knowledge of the structure and flow of content. In some cases, it even changes the content flow on the fly to provide personalization. Though most LCMSs provide detailed tracking of all interaction between the user and the content, the mechanism of how the tracked information in the LCMS is rolled up and sent to the LMS is an important consideration for the smooth functioning of the combined systems (Oakes, 2002). However, standards such as SCORM (sharable content object reference model) have been created to address the interoperability between content and LMSs specifically. It can therefore be assumed when an LCMS is said to be

SCORM compliant, it would interoperate smoothly with any SCORM-compliant content (LMS standards are presented in Chapter 2).

Greenberg (2002) also agrees with Oakes (2002) that although the LCMS and LMS have a different focus, they integrate very well. While the LCMS allows for the creation and delivery of learning objects (LOs), the LMS manages the learning process as a whole, incorporating the LCMS within it. In other words, as Connolly (2001) put it, the LMS provides the rules and the LCMS provides the content. Thus, depending on what they offer out-of-the-box, different naming conventions are used to refer to software applications (systems) that are used to support online learning. In earlier adoptions, LMSs, CMSs and LCMSs have all been used. Later, as new tools were embedded to enhance learner interactions, new naming conventions have also emerged, such as Virtual Learning Environments and Collaborative Learning Environments, Managed Learning Environments (MLEs), Learning Support Systems (LSSs) and Learning Platforms (LPs).

In this study, LMS is used to refer to the entire family of these systems. After all, the LMS systemic nature (Greenberg, 2002) provides the structure within which they all function.

Related studies, such as those by Dagger *et al.* (2007), Hadjerrouit (2010), Hargis *et al.* (2012) and Sharma *et al.* (2013) have also defined VLE, CMSs, LCMSs, MLE, LSSs, and LPs collectively as LMS: Web-based software application platforms that use Web technologies and Internet services to support online course creation, maintenance and delivery; student enrolment and management; and education administration and student performance reporting. In addition, these systems allow learners to use interactive features such as threaded discussions, chat rooms, discussion forums, and other methods of communication between them, with the teachers, and with the university.

### **1.1.2 The Drivers Behind LMS Adoption: Role of LMSs in Education**

As Watson (2007) asserts, the importance of understanding the LMS, as well as its related technologies, lies in the role it plays in the current approaches to instruction as the needs of today's learners cannot be met by technology-free instruction approaches alone. The LMSs and related technologies, such as the Internet, have provided new directions in teaching and learning, and have had a significant impact on the ways in which teachers interact with students. Student instruction has moved to a more learner-centred approach as teachers cease acting primarily as knowledge sources and instead become facilitators of the knowledge

acquisition process by acting as guides, coaches and motivators as students become more active in their learning process (McCombs and Whisler, 1997). In order for the learner process to be customized for individual learners, technologies such as LMSs need to play a key role. It is also true that technology is needed to track each student's progress towards mastery, assess their learning, help teachers understand what sort of guidance is needed, provide and appropriately sequence instruction, store evidence of attainments and systemically integrate each of these functions. This description of what might be the role of technology in education is closely aligned to the functions of LMSs and, as a result, LMSs have been widely adopted by universities. In fact, as Cavus *et al.* (2007) argue, it is difficult to identify many universities that do not use an LMS of some sort. LMSs are regarded as the most basic and reliable e-learning tools in blended learning environments, and they are often viewed as the starting point of any Web-based learning program (Cavus *et al.* 2007).

Furthermore, from an institution's perspective, while an LMS may not be the overall solution to online learning, many institutions view it as the glue that holds everything together (Norman, 2013). For example, it provides: access to courses; management of students' grades; a core set of tools and resources for offering courses online; tracking of students' activity; access to resources; and connecting assignments to grades. Sharma *et al.* (2013) also highlight the following advantages for the use of LMSs in academic institutions:

- Using the correct learning strategies, LMSs can increase motivation of learners, promote learning, encourage interaction, provide feedback and support can be provided during the learning process.
- A learning management system supports content in various formats, e.g. multimedia, video and text.
- Access to course material is at anytime. Course material is updated and students can see the changes made in the particular field. Teachers can modify information according to the needs of the student.
- Re-use of the learning activities can be done. By re-using content, time and effort can be saved and the cost of improving online content is also reduced.

In addition, non-academic sources also credit LMSs for:

- Facilitating a 24/7 information sharing portal among tutors as well as students and between tutors and students;
- Learners' use of LMSs to receive course support inputs, additional updates, attempting self-test quizzes and interacting with course coordinators, tutors and peers

via the public forums, tutorial forums, discussion boards and the study groups created by them;

- Monitoring the online interaction between tutors and learners and making a comparative assessment of learner support provided by different tutors of the same course; and
- Learners' use of the LMS tends to enhance their performance in assessments.

Institutions therefore continue to seek ways through which to effectively and more satisfactorily implement the LMSs. Enabling access of the LMS services by the students through multiple devices could be one way of achieving this goal.

Besides the advantages that the LMSs promise to offer to institutions, such as those outlined above, Coates *et al.* (2005) also identified the most likely drivers behind LMS adoption that compel (or seem to compel) almost every academic institution to have one. These include:

- i. Learning management systems increase the efficiency of teaching by offering institutions a means for delivering large-scale resource-based learning programmes. In addition, despite the large upfront capital investments required, universities are attracted by opportunities to reduce course management overheads, reduce physical space demands, enhance knowledge management, unify fragmented information technology initiatives within institutions, expedite information access, set auditable standards for course design and delivery and improve quality assurance procedures (Dutton and Loader, 2002; Katz, 2003; Coates *et al.* 2005). Learning management systems also offer universities new economies of scale.
- ii. Learning management systems are associated with the promise of enriched student learning. Coates *et al.* (2005) report that, LMSs, and online learning in general, are seen to reinforce and enhance a diverse suite of constructivists. Constructivist theorists contend, for instance, that online modes can enrich learning by allowing students to access a greater range of resources and materials (Gillani, 2000; Jonassen and Land, 2000). It is further argued that Internet technologies can be used to make course content more cognitively accessible to individual learners by allowing them to interact with diverse, dynamic, associative and ready-to-hand knowledge networks. LMSs may also enrich learning by providing automated and adaptive formative assessment, which can be individually initiated and administered (Coates *et al.* 2005).
- iii. Universities are driven by new student expectations. Student expectations for advanced technologies are increasing almost as quickly as the technologies are

developing. Coates *et al.* (2005) quote Green and Gilbert (1995) that growing numbers of college-bound students come to campus with computer skills and technology expectations and Frand (2000) agrees that contemporary students have an information-age mindset, and that these skills and expectations are tacit and profound. In the increasingly competitive higher education marketplace in which students are increasingly perceived as some type of client (Gilbert, 2001), these expectations need to be matched or exceeded. Thus, it is increasingly expected that institutions embrace leading-edge technologies. Green and Gilbert (1995) also pointed out that the old competitive reference points describing information resources that used to distinguish between institutions – the numbers of science labs and library books – are being replaced by a new one: information resources and tools available to students.

- iv. Competitive pressure between institutions has also been and continues to be a driver behind the adoption of LMS by the institutions. Traditionally distance-learning orientated institutions have embraced LMSs to reconfigure and expand their programmes. Campus-based teaching institutions have also seen the adoption of LMSs as necessary for developing the campus environment. Coates *et al.* (2005) further argues that almost regardless of their history or strategic direction, institutions have seen LMSs as a means of leveraging the Internet to offer some kind of competitive advantage.
- v. Learning management systems are seen as the means of responding to massive and increasing demands for greater access to higher education and, more significantly, the LMSs have also been identified as a means of qualitatively reforming higher education so that it can most effectively confront new types of demand.
- vi. Learning management systems are part of an important culture shift taking place in teaching and learning in higher education. They are seen to offer universities the much needed capacity to control and regulate teaching. Coates *et al.* (2005) further state that the management and leadership of academic communities require a high tolerance of uncertainty, but such tolerance is in increasingly short supply in an era of attention to quality assurance and control. LMSs may appear to offer a means of regulating and packaging pedagogical activities by offering templates that assure order and neatness, and facilitate the control of quality. The perceived order created in teaching and learning by LMSs is one of the more persuasive reasons for their rapid uptake.

Considering the advantages and the drivers behind LMS adoption, LMSs are clearly important to academic institutions, so worth studying. It was also established by this study that despite the increased adoption of LMSs by academic institutions, the majority of developing country universities are struggling to enjoy the full benefits of the LMSs due to the various constraints that limit LMS accessibility and use by the students.

## **1.2 Research Motivation and Problem**

The belief that LMSs have had (and will continue to have) a profound impact on the way educational institutions serve their students has led to: high investments into the LMSs by universities; and high expectations by both the universities and the students about what they can achieve through the LMSs. However, a background survey, which was carried out as part of this work, revealed that, although universities in developing countries have increasingly adopted and invested into the LMSs, most of the universities and students have not been able to sufficiently exploit the full benefits of the LMSs.

In one of the universities that were surveyed, there had been several previous LMS-supported e-learning initiatives in which the researcher was involved. None of the initiatives registered great success. This led to questions as to whether the problem of limited success with LMSs was unique to this one university – what was the situation like in other universities in the region and beyond? How could the LMSs be implemented to greater success in that university and other universities operating under similar conditions? There was scant information and little specific literature about LMS implementation in developing country universities to answer these questions. The available literature, however, revealed that, in the developed countries, LMSs have been implemented and used to greater success (Paulsen, 2003; Masutu, 2012). This, therefore meant that the barriers to more successful implementation of LMSs were most likely local or regional and required targeted solutions.

A background survey was thus conducted to map out the problem space. The survey involved key e-learning personalities from five African universities. The key e-learning personalities were defined as the officers who were in charge of e-learning in the selected universities. These had varying titles that included e-learning coordinators, e-learning team leaders, e-learning managers and educational technology directors. The surveyed universities were found to have limited success with LMSs and there was a high turnover of LMSs as the universities sought to find the most appropriate LMSs to work better in their environments. However, it was noted that the limited success of LMS-supported e-learning initiatives in the

surveyed universities had little to do with the LMSs but more to do with the constrained ICT infrastructure in these universities, which made it difficult for the students to access the LMS services. The systems remained mainly unused by the students and, as a result, the teachers/instructors also abandoned them. Thus, the observed high turnover of the LMSs in the universities that were searching for the most appropriate systems could not be justifiable; instead, the universities were running the risk of diverting resources and energy into managing transitions. An exception was where such changes were motivated by financial considerations: for example, changing from commercial to open source LMSs. The factors that were identified through the survey as the barriers to more successful implementation of the LMSs included: limited ICT infrastructure such as LANs; few computers; limited and expensive Internet bandwidth; power outages; low ICT-literacy rates and low comfort levels using ICT-solutions among the students; LMS usability issues; ineffective maintenance and inefficient user support strategies; high and unrealistic expectations, and poor marketing strategies. These are described in more detail in Chapter 3 of this thesis.

From the findings of the survey, it was apparent that, for LMSs to be implemented more successfully in the surveyed universities, and indeed other universities working in similar conditions, further research and development efforts should be aimed at identifying strategies of reducing (or overcoming) the impact of the above challenges, that is, identifying ways of using the existing ICT infrastructure to support the implementation of LMSs, notably, enabling students' LMS access through mobile devices.

In a subsequent survey (that was carried out in two universities), in which students were the primary respondents, it was found out that the students' access and use of the LMSs was indeed mainly constrained by the universities' limited ICT infrastructure (such as computers, LANs and electricity outages). The survey further revealed that, although the majority of students (99%) possessed mobile phones, of which 70% were Internet phones (mobile phones that can technically read and display full desktop websites such as the LMSs), they never used their mobile phones to access the LMS services. Yet, mobile phones would be less affected by power outages and the non-functional or the lack of LANs. In the survey, the students claimed that mobile phones presented usability and compatibility problems in trying to use them to access LMSs (detail of this survey are also presented in Chapter 3). This claim by the students was consistent with the constraints of using mobile phones to access full websites meant for desktop and laptop computers, as documented in literature (Fling, 2009; Jones and Marsden, 2006; and Nielson, 2012). However, it was also noted that even where

mobile LMS interfaces existed, they were largely unused by the students, suggesting that the designs of the mobile LMS interfaces were inadequate. It was thus apparent that the students required more usable mobile LMS interfaces to encourage them to access LMS services on their mobile phones. If that could be achieved, it would allow the students to access LMS services on their mobile phones more easily and would also reduce the over-reliance and the pressure on the institutional ICT resources for accessing the LMS services all the time by the students. After all, literature on mobile learning (such as Ford and Botha, 2007; Minovic, 2008; and Botha *et al.* 2010) states that mobile devices have the potential to be integrated into the classroom because they contain unique characteristics such as: portability, social interactivity, context sensitivity, connectivity and individuality. In fact, Ford and Botha (2007) suggested that the use of a mobile phone as technology tool to aid the learning process can work extremely well in Africa, as the barrier of entry is very low – the learners themselves are very open to using the technology and the teachers could focus on facilitating the learning process, rather than having to grapple with new, unfamiliar technologies (as is the case with traditional computers).

### **1.3 Objective, Research Questions and Methodologies**

#### **1.3.1 Research Objective**

The main objective of the study was to identify strategies for using the available ICT infrastructure in developing country universities to better support the implementation of LMSs, to enhance the accessibility of LMSs services by the students.

#### **1.3.2 Research Questions**

Acknowledging the unique challenges and constraints (such as those highlighted above) that are facing universities in developing countries, how can we better use the available ICTs and ICT infrastructure in developing country universities to enhance the accessibility of the LMS services by students to better support the implementation of LMSs? ('Better' in the sense that the students are able to access the LMS services more easily and more satisfactorily).

The study explored the ecology that surrounds LMSs in developing country universities to understand the students' activities that need to be supported by the LMSs and the possibility of partitioning the services of the LMS for accessibility through the most available devices – the mobile phones.



The following specific research questions guided this study:

- i. What is the current status of LMS implementation in developing country universities?
- ii. What services of the LMS are more needed and required by the learners in developing country universities?
- iii. How can we partition the services of an LMS for accessibility through mobile computing devices such as mobile phones?
- iv. Does enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces have any impact on the students' access behaviours/patterns of the LMS services?

### **1.3.3 Methodologies**

To address the research questions above, various research methods such as questionnaires, interviews, experimentation and analysis of user logs were used in an iterative and user-centred approach.

The use of various research methods, as demonstrated in this study, is described by some researchers as triangulation of research methods and philosophies. It is supported by various scholars such as: Crossan (2003); Polit *et al.* (2001); Gable (1994); Webb (1989); and Kaplan and Duchon (1988). In fact, Crossan (2003) argues that, while quantitative research methods (or positivist philosophies) and qualitative methods (or post-positivists philosophies) are often seen as opposing and polarised views, the distinction between the methods and philosophies is overstated, and they are frequently used in conjunction.

For example, in this study, the surveys into the ecologies that surround LMSs implementation in developing country universities were the subject of exploration research, which also featured descriptive and empirical methods. According to Gay *et al.* (2006), descriptive research determines and reports the way things are and it involves collecting data to answer questions about the current status of the subject of study, for example, through assessing the preferences, attitudes, practices, concerns, or interests of groups of people (Akour, 2009). This was the case in this study where the current practices and concerns of LMSs implementation in developing country universities were probed through interviews with key-e-learning personalities from five African universities. The findings obtained through the interviews are presented in chapter 3 and were useful in answering research question (i). Research question (ii) was answered by data obtained through an online survey questionnaire that was carried out in two universities, in which students were the primary respondents. Research question

(iii) was answered through experimentation that included participatory design, focus groups and user experience evaluation, and some best practices identified through literature review. Mobile LMS interfaces with selected LMS services were designed and a mobile LMS (mLMS) application was developed, implemented and evaluated through prototyping and revised through student feedback. The final prototype was then deployed for a longitudinal evaluation from which students' reports and user logs were obtained and analysed. The information obtained from the analysis of user logs and the user reports was used to answer research question (iv).

The design, development, implementation and evaluation of the mLMS application (the intervention of this study) was achieved through a user-centred design approach (Hadjerrouit, 2010; Murphy, 2004; Penna *et al.* 2007 and Petrelli *et al.* 2005), as shown in Figure 1.1.

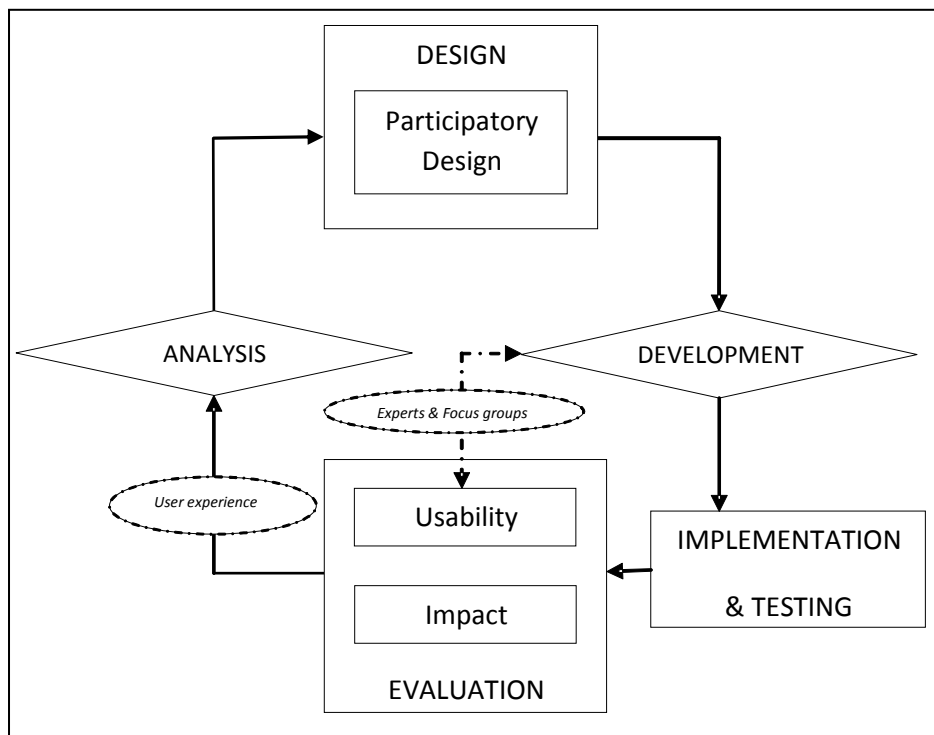


Figure 1.1: mLMS application development cycle (Methodological Framework)

Figure 1.1 above shows the process of creating the mLMS application (the intervention) starting with design, development, implementation and testing, evaluation and analysis. The design of the mLMS was achieved through a participatory design process with the students. The design process started with paper prototyping. The paper prototype was then developed into a working prototype (mLMS application). The mLMS application was evaluated for usability, first by HCI experts and user focus groups in a controlled environment. Actionable

feedback from the experts and focus groups was incorporated into the prototype (development). Then, the prototype was further evaluated for usability by the users in the real context (user experience evaluation). The feedback from the user experience evaluation was analysed to identify actionable faults and requirements, which were also incorporated into the prototype (design and development). The prototype was again implemented and tested, and an impact evaluation was carried out, including an analysis of user logs. The results of the impact evaluation were critically analysed to determine if the intervention produced the desired effects and to determine whether the observed effects could reasonably be attributed to the intervention.

## **1.4 Conceptual and Theoretical Framework**

### **1.4.1 Conceptual Framework**

Nalzar (2012) defines a conceptual framework as one that: consists of concepts that are placed within a logical and sequential order; and one that is based on specific concepts and propositions derived from empirical observation and intuition. The conceptual framework of this study was based on the LMS accessibility setup presented in Figure 1.2.

The LMS is conceptualized as residing on a server and accessed by the students through the Internet using various devices such as as desktop computers, laptop~~s~~ computers, and mobile devices such as the mobile phones.

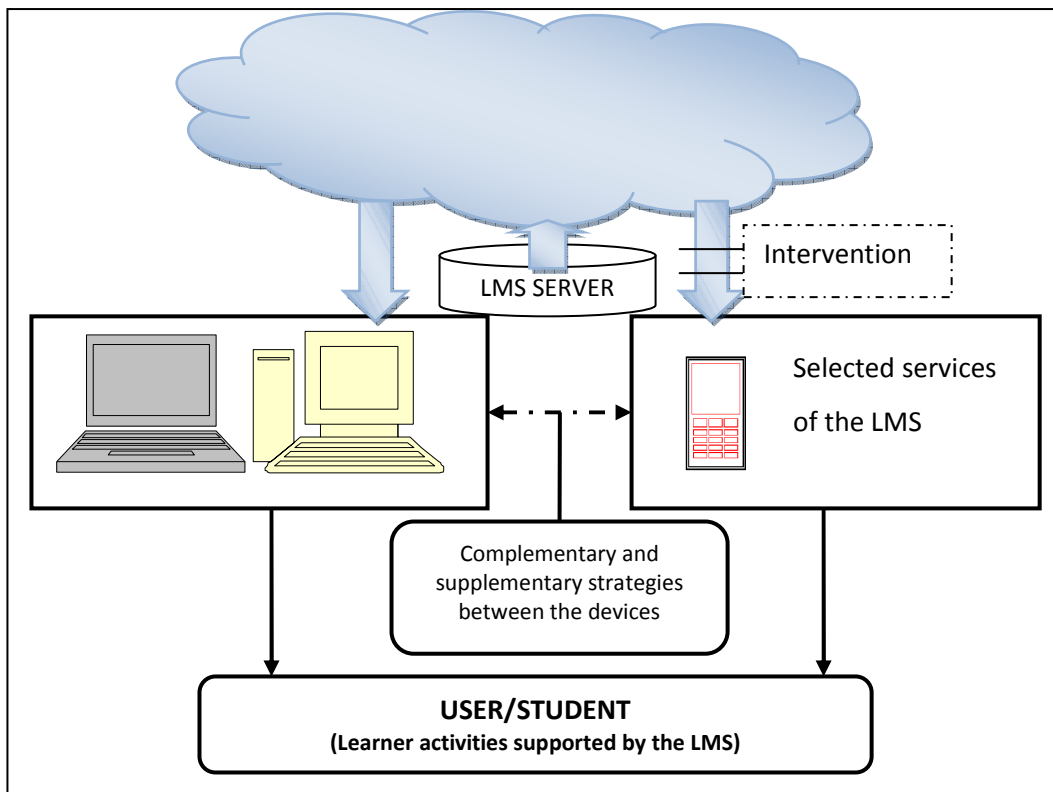


Figure 1.2: LMS accessibility setup

The intervention shown in Figure 1.2 is intended to enhance the accessibility of LMS services through mobile phones. Based on the students' claims that the available LMS interfaces were unsuitable for accessing the LMS services on their mobile phones, the proposed intervention involved the design, development, implementation and evaluation of more usable mobile LMS interfaces to allow access of selected LMS services on the mobile phones. The selected services were identified by the students as the most needed and most required LMS services. Enhanced accessibility of the LMS through the mobile phones would allow students to access the LMS services more easily and 'on the go' given that the majority of them possess mobile phones. Overall, this would increase the accessibility of the learning resources provided through the LMS and it would also reduce the pressure on the already constrained institutional ICT infrastructure (such as the computer labs) for the students' access of LMS services. As shown in Figure 1.2, both the devices (computers and mobile phones) would be complementary and supplementary to one another in that either of them would be used to access the LMS services in situations where the other may not be suitable or not available.

### 1.4.2 Theoretical Framework

Literature suggests that, in order to truly integrate e-learning systems into regular curriculum at universities, mobile access to the systems has to be enabled. For example, Minovic *et al.* (2008) and Woodill (2010) argue that mobile devices contain unique characteristics such as: portability, social interactivity, context sensitivity, connectivity and individuality, which make them suitable to be integrated into the classroom. Keegan (2002) and Valk *et al.* (2010) also contended that the use of mobile phones in education broadens the availability of quality education materials through decreased cost and increased flexibility while also enhancing the efficiency and effectiveness of education administration and policy. Valk's study confirmed the theory that supports the impact of mobile phones on educational outcomes and reiterated that mobile phones impact educational outcomes by improving access to education while maintaining the quality of education delivered. The integration of mobile phones into the LMS ecology is seen to increase the students' accessibility to the learning resources that are provided through the LMS and, in turn, this will translate into students' increased learning.

Mobile learning literature, however, also suggests that, despite the ubiquity of mobile phones, their integration into teaching and learning is still limited by several factors such as the smaller screens, high latency and limited functions (Ahonen *et al.* 2003; Roschelle, 2003). Because of the small screens of the mobile devices, Ahonen *et al.* (2003) theorise that if the mobile phones are to be used effectively to access learning materials, the interfaces should be built in such a way to facilitate proper navigation to allow the learners to move between screens more easily. Furthermore, Dix *et al.* (2006) also highlight the need for mobile e-learning applications to be able to adapt themselves to the students' learning styles and to assure high standards of accessibility and usability, in order to make learners' interaction with the systems as natural and intuitive as possible.

Mobile learning in developing countries is still a new research area (Mwanza, 2007; Multisilta, 2008), and the integration of mobile phones into the LMS ecologies to benefits students in developing countries still requires the building of theoretical concepts and frameworks for supporting the design and implementation of usable and useful mobile LMS interfaces for the students. Some theoretical concepts are generated from this study and, in addition, conclusions from this study highlight the importance of HCI techniques and the user-centred development approach in the design and development of usable and useful e-learning applications.

## **1.5 Scope of the Study**

This thesis provides an insight into the challenges that surround the implementation of learning management systems in developing countries. As is apparent from the formulation of the research objective and research questions, the focus was on identifying strategies for effective implementation of the LMSs in developing countries. After mapping out the problem space of LMS implementation in the developing countries, an intervention was designed, developed, implemented and evaluated.

A critical review of literature provided a theoretical basis on how to design usable and effective mobile interfaces and applications. Through surveys, university students informed the study about the most needed and most required LMS services that would have to be provisioned on the mobile phones. The design and development process took a user-centred design approach and the product was evaluated using standard usability and impact evaluation procedures.

The study does not deal with the development of learning content (objects) in the LMS, which require that pedagogical principles and learning theories are given due consideration. It assumes that the necessary learning objects (resources) are available on the LMS. Therefore, the outcome of this study is to enhance learning effectiveness from the point of view of increased/enhanced accessibility to the learning objects.

## **1.6 Thesis Contributions**

Although the surveys carried in this study explored all the issues relating to the use of LMS in developing country universities, which revealed and extended LMS related literature, the primary contributions of this thesis mainly relate to the development of streamlined mobile LMS interfaces for enhancing LMS access through mobile devices. This would in turn reduce the impact of the institutional ICT infrastructural challenges that limited students' access of the LMS services.

While some of the identified LMS challenges remain unaddressed, the specific contributions of this thesis are as follows:

Firstly, this thesis extends the current LMS-related literature by:

- i. Presenting the factors that are responsible for the limited success of LMS supported e-learning initiatives in developing country universities. These factors were identified through a survey conducted in five universities in Africa, and the findings were useful

in answering research question (i) of this thesis. With an understanding of these factors, targeted solutions can be designed, as was the case for the intervention implemented in this study.

- ii. Identifying and presenting the students' experiences and expectations of the learning management systems in developing country universities. These were obtained through a survey in which students were the primary respondents. The findings were useful in answering research question (ii). Understanding the students' expectations of the LMSs would help the LMS designers to pay more attention to the LMS services that are more needed and desired by the students, as was the case in this study when designing the streamlined LMS interfaces for mobile access.

Secondly, user-centred design approaches: participatory design; co-design sessions; prototyping; and user evaluation were successfully applied in the design, development and evaluation of the mobile LMS application presented in this work. The outcomes of these were useful in answering research questions (iii), (iv) and (v).

- i. These methods were applied to this study with specific insights and considerations, which can be emulated in similar studies/interventions.
- ii. This re-affirms the importance of such approaches in designing usable systems.

Thirdly, the mobile LMS application that was created as a result of this work was useful and continues to be useful to the students as they use it in accessing the services of the LMS on their mobile phones,

Fourthly, practice-oriented reflections (theoretical concepts) for supporting the design, development and implementation of usable and useful mobile LMS interfaces for the students were generated from this study. These include:

- i. Learning management systems need to be componentised for better accessibility through mobile phones.
- ii. Access of LMSs through the mobile phones should be service-based, as opposed to course-based (and to have information e.g. the announcements merged from across courses) and that the mobile LMS application should be made as simple as possible and non-crowded, that is, fewer LMS services (the most needed/desired services) should be made accessible through mobile phones.

- iii. The creation of usable and useful mobile LMS interfaces needs to have the students at the centre of the design and development process.
- iv. Mobile LMS applications can be developed as cross-platform Web-based applications as opposed to native applications and still be useful to the students.

## **1.7 Organisation of the Thesis**

This thesis consists of six chapters. Chapter one, the introduction, gives an overview of the study including defining the LMS and related terms and, the role of LMSs in education. The chapter puts the rest of the study into perspective towards identifying and defining the research problem and the identified intervention. The problem addressed in the study is the limited success of LMS implementation in developing country universities due to a number of factors, some of which have been identified and highlighted in this study. In relation to the problem, the motivation was described and the research objective was stated. Following the research objective, the research questions were stated, followed by an outline of the methods through which each of the research questions was addressed. This chapter then presents the conceptual and theoretical underpinning of the study followed by the thesis contribution and the scope.

Chapter two (literature review) presents and critically analyses the literature that is related to this study. The reviewed literature provided an understanding about LMSs, including: the generations, standards, categorisation and use of LMSs; and the LMS ecology. As the study identified the need to design, develop and implement more usable mobile LMS interfaces, the reviewed literature also included the state of practice in mobile application development; the need and the existing efforts towards integrating mobile phones into the LMS ecologies, including an overview of the theories in support of mobile learning. The chapter then identifies the gaps in the current efforts in the research area and identifies the most appropriate approaches and methodologies to be used in the design, development and evaluation of the mobile LMS intervention that was implemented in this study

Chapter three presents and discusses the findings of two surveys that were carried out in this study to investigate the status of LMS implementation, limitations and students' use and expectations of LMSs in developing country universities. The findings from the two surveys were useful in identifying strategies for more successful implementation of the LMSs in



developing country universities. Specifically, the survey findings were useful in answering research questions (i) and (ii) respectively.

Chapter four presents the design and development of the intervention, which is the mobile LMS (mLMS)–mobile Vula (mVula). The mVula application was designed and developed to the specifications and with involvement of the students in a participatory design process. The chapter highlights: the justification for the user-centred development approach for mVula; the process involved, including paper prototyping; the technologies and the justification of the technologies used for the development of the client side and the back end of mVula; the mLMS architectural framework; and the description of the mVula system setup. The chapter then describes the functionality and presents screenshots of the interfaces of the developed mVula application. The mVula development process was also useful in answering research question (iii).

Chapter five (evaluation) presents the description of the evaluation process, the results and the discussion of the evaluation results of the mVula application. The chapter has two main sections: the section that reports on the evaluation of the ease-of-use and perceived usefulness of mVula (achieved through expert evaluation, focus group evaluation and user experience evaluation) and the section that reports on the impact evaluation of the application (achieved through students' self reports and the analysis of the Vula user log files). The findings from the impact assessment were useful in answering research question (iv) of the study and drawing specific conclusions that are stated in chapter six.

Chapter six, which is the last chapter of this thesis, contains four major sections: the section that presents the summary of the study, revisiting the study problem and the research questions and highlighting how each research question was addressed; section that presents the conclusions deduced from the study; and the sections that highlight the study limitations and future research directions respectively.

## CHAPTER 2: REVIEW OF RELATED LITERATURE

### 2.1 Introduction

This chapter presents and critically analyses the literature that is related to this study. First, it presents the literature that provides an understanding about LMSs. This includes: the generations, standards, categorisation and use of LMSs; and the LMS ecology. As the study identified the need to design, develop and implement more usable mobile LMS interfaces, this chapter also presents and analyses literature on the state of practice in mobile application development. The chapter then presents literature on the need and the existing efforts towards integrating mobile phones into the LMS ecologies, including an overview of the theories in support of mobile learning. It then identifies the gaps in the current efforts in the research area and identifies the most appropriate approaches and methodologies to be used in the design, development and evaluation of the mobile LMS intervention that was implemented in this study

### 2.2 The LMS Generations, Categorization, Use and Ecology

#### 2.2.1 LMS Generations and Standards

Literature reveals three LMS generations: the first generation, the second generation and the third generation. According to Dagger *et al.* (2007), the first generation systems (from about 1993) were monolithic and supported content-only interoperation. During this generation, a range of standards emerged, such as Dublin Core (DC), IMS Learning Resource Metadata (LRM), and IEEE Learning Object Metadata (LOM) (Table 2.1). The first versions of WebCT and Blackboard are examples of these early e-learning platforms.

The second generation systems are largely modular; they take account of users and their associated profiles and focus not only on sharing content but also on sharing learning objects, sequences of learning objects and learner information (Dagger *et al.* 2007; Leal *et al.* 2011). The standards that have emerged during this generation include Shareable Content Object Reference Model (SCORM<sup>5</sup>), IMS<sup>6</sup> Content Packaging and IMS Learning Design. In

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<sup>5</sup>SCORM: [www.adlnet.gov](http://www.adlnet.gov)

<sup>6</sup>IMS: [www.imsglobal.org/specifications.html](http://www.imsglobal.org/specifications.html)

addition, the second generation of learning management systems: are domain independent; have integrated authoring tools; provide the design and publication of reusable learning resources; and are virtually independent of any specific hardware platforms (Brusilovsky and Peylo, 2003). The second generation LMSs are also Web-based, and the majority of these are the current LMS generation such as Moodle, Sakai and WebCT/Blackboard. However, these are increasingly being developed towards Semantic Web and adaptive hypermedia and are focusing on targeted personalization and letting consumers choose the right combination of services for their requirements (service oriented) – i.e. third or future generation. Table 2.1 below shows the LMS generations and the major standards that characterise each of the generations.

Table 2.1: Generations and standards of LMSs

	<b>FIRST GENERATION</b>	<b>SECOND GENERATION</b>	<b>THIRD GENERATION</b>
METHODS	Monolithic	Modular	Service-Oriented
STANDARDS	<div> DC; RDF AICC CMI </div> <div> LRM LOM </div>	IMS-Content Package IMS LIP IMS enterprise IMS LD; OKI SCORM	IMS abstract framework IMS TI ePortoflio ELF
TECHNOLOGIES	Stand-alone	Web-based	Adaptive Hypermedia Semantic Web
-----Time-----→			

Source: *Re-drawn from Dagger et al. (2007)*

This study focused on the current (second) generation of LMSs. These systems have been widely adopted and used by academic institutions.

## 2.2.2 Categorisation and Use of LMSs

Although earlier studies such as by Fertalj *et al.* (2006) recognised four categorises of learning management systems, namely:

- Proprietary LMSs
- Mainly proprietary and partially standards-based LMSs, denoted as “proprietary/standard”

- Mainly standard-based LMSs and partially proprietary LMSs, denoted as “standard/proprietary”
- Open architecture LMSs,

the current breed of learning management systems can precisely be put under two categories:

- i. Proprietary/commercial LMSs
- ii. Open source LMSs

### **2.2.2.1 *Proprietary vs. Open Source LMSs***

The proprietary LMSs are developed by commercial entities and attract licence fees for the institutions wishing to use them, while open source LMSs are freely available for the institutions and individual users to download, modify, use and even distribute (under the terms of the GNU General Public License). It is, however, also important to note that some LMSs such as AdrennaLearn<sup>7</sup> and Instructure Canvas<sup>8</sup> are built on open source platforms but are available only from the vendors and not as free downloads. While there are also LMSs such example Edmodo<sup>9</sup> that are not commercial in the sense that they do not require payments for use, but are not open source either.

The current market share of the LMSs (Figure 2.1) shows that among the commercial LMSs, Blackboard (especially when its acquisition of its main competitor WebCT is taken into consideration) is the leading contender, while Moodle and Sakai are some of the most popular among the open source LMSs.

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<sup>7</sup> AdrennaLearn: [http://www.adrenna.com/open-source-lms#adrenna\\_academic](http://www.adrenna.com/open-source-lms#adrenna_academic)

<sup>8</sup> Instructure Canvas: <http://www.instructure.com/>

<sup>9</sup> <https://www.edmodo.com/>

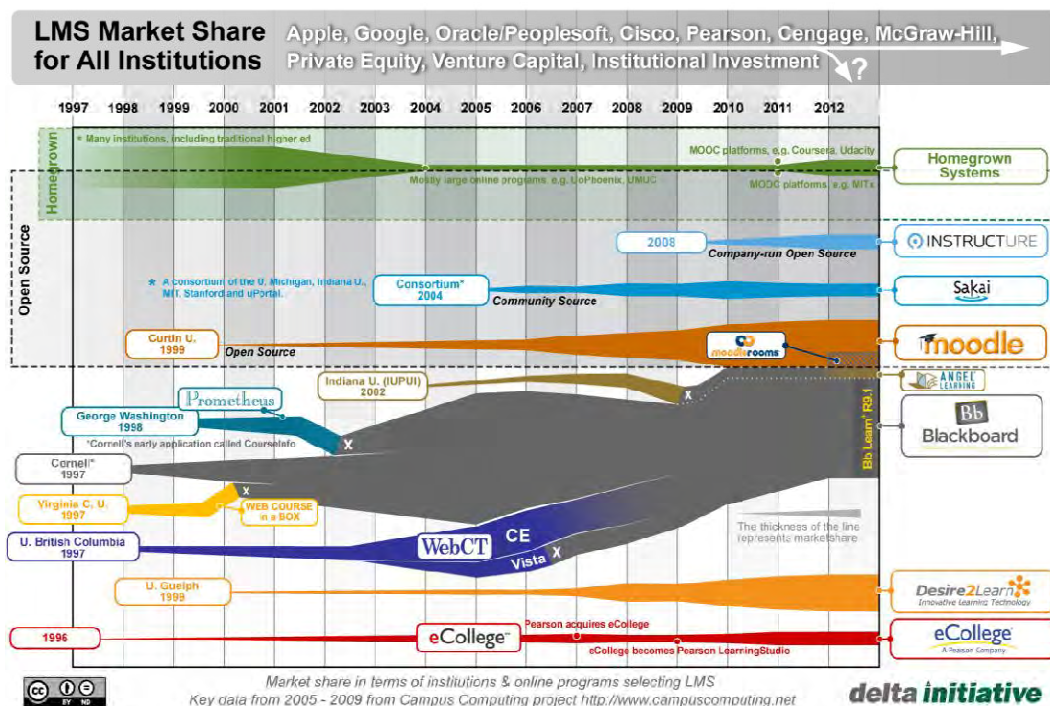


Figure 2.1: Market share of some LMSs

(Source: <http://mfeldstein.com/state-of-the-higher-education-lms-market-a-graphical-view/> with permission from the e-Literate)

While the proprietary LMSs dominated the market since the inception of LMSs, open source LMSs have gained increased recognition and adoption by educational institutions. There are a number of reasons why many institutions are turning to open source learning environments but, according to Smart (2005), scalability and flexibility are particularly the most important. Scalability in the sense that the open source LMSs allow institutions to have as many users as they like without incurring larger license fees; and flexibility in the sense that institutions can choose to develop the open source environment to meet their particular needs. According to Lakhan *et al.* (2008), in general, the following are some of the factors that have tipped the balance towards open source software systems in educational institutions:

- *The absence of a license fee.* Most universities annually pay large sums to software companies to use their products, but open source licenses are free.
- *Flexibility.* Open source products are customizable and can involve third parties. New features and tools can be imported from the open source community.
- *Service continuity.* The huge collaborative network of the open source community minimizes, although it does not eliminate, the risk of discontinued service. Volunteer help is available through open source support systems, such as forums.

- *Cooperative development.* Open source removes the commercial imperative to compete, enabling genuine cooperation between developers and institutions, among developers and between projects.
- *Continuous improvement.* Extensive collaboration ensures that software products keep improving. Programmers from different institutions and organizations, along with volunteers, contribute freely to projects.
- *Tax benefits.* Governments of many countries have implemented tax-exemption policies to boost open source projects, although the governmental role in promoting open source software is controversial (Hahn *et al.* 2002).

However, as Hargis *et al.* (2012) remark, institutions ought to consider that open source does not mean free in monetary terms. While it is true that there are no license costs, other costs attributed to training, support and implementation could rise to a substantial amount, especially when an institution is not prepared in terms of culture and human resources to enter the open source arena. Additionally, as various researchers have noted, open source educational software also has notable drawbacks such as the following:

- The most alarming one is possible loss of support. Typical end users are not interested in the availability of source code; they are more concerned with the software's usability. This is one reason commercial software companies commit resources to product documentation and customer support. Lakhan *et al.* (2008) also argues that the lack of commercial incentives in many open source projects undoubtedly reduces some contributors' enthusiasm, and when the support system disappears, institutions may get into trouble when improving and customizing their open source products.
- The problem resolution procedures among the systems are quite different. With a commercial system like Blackboard, usually the problem is logged or ticketed and then someone is assigned to your problem. With an Open Source system such as Sakai you need to search the user forums and if no one else has had the same problem, you then submit your problem to the forum hoping that someone can help. This can sometimes be problematic, more so if the problem is critical (Bremer and Bryant 2005).
- While the software is free, the overall cost of running an Open Source product is not nil. Substantial institutional support is necessary, so the total cost of ownership must be addressed. It is noted that open source software may have a higher installation cost

(due to time). This cost is primarily in the installation stage when initial configuration and tuning of the system is occurring.

- There are also potential drawbacks of open source projects for education during their implementation. Using the software to its full potential may prove challenging for beginners, and the availability of the source code is irrelevant for end users if they do not find the product useful. And there are no guarantees that a project will reach completion and deliver the desired results (Lakhan *et al.*, 2008).

Table 2.2 below summarises some of the other advantages and disadvantages of proprietary and open source LMSs

Table 2.2: The Advantages and disadvantages of Proprietary and Open source LMSs

	Proprietary LMSs	Open source LMSs
<b>Upside</b>	<ul style="list-style-type: none"> <li>• Support from the vendor to get up and running</li> <li>• Institution would benefit from the vendor's deep industry knowledge</li> <li>• Highly scalable and grows with business needs</li> <li>• Rich documentation for admin staff and users available</li> <li>• Vendor is accountable for service, updates and offers single point of support</li> </ul>	<ul style="list-style-type: none"> <li>• Free to try experiments and update</li> <li>• Flexibility and freedom to adopt solutions from different resources</li> <li>• Ability to control and customise</li> <li>• Access to source code and community support</li> <li>• Often uses open standards</li> </ul>
<b>Downside</b>	<ul style="list-style-type: none"> <li>• License fees, which make them unsuitable option for institutions with limited financial resources.</li> <li>• Limited integration options at best</li> <li>• Control of the commercial provider over the institution in terms of upgrade or change</li> <li>• Generally not customisable without vendor buy-in or client pay-in</li> <li>• Difficulty in exporting content when an institution decides to switch vendors</li> <li>• Potential lack of APIs or connectivity</li> </ul>	<ul style="list-style-type: none"> <li>• Requires skills in-house to service, update and support</li> <li>• Intellectual property may be held by an individual, which might lead to an unknown roadmap in terms of product development and source availability</li> <li>• Potential deviations from core, complicating migration and upgrade</li> <li>• Possible loss of support</li> <li>• Projects may be abandoned or underdeveloped</li> </ul>

The downside of the commercial LMSs notwithstanding, the advantages of the open source LMSs have compelled many universities to adopt open source LMSs. The absence of licence fees is particularly important for universities in developing countries, given that most of them operate with limited budgets.

Earlier studies (such as Matusu, 2012; Ludivine, 2009; Yuhui Li, 2009; Machado *et al.* 2007; Bremer *et al.* 2005; and Munoz *et al.* 2005) also reveal that Moodle and Sakai are the most adopted open source LMSs in developing countries.

### **Moodle and Sakai**

Being open source, both Moodle and Sakai are built on top of numerous third-party open source libraries and frameworks, re-using code such as for converting from XML text files to Java objects, connecting and managing databases, etc. Using third-party frameworks has benefits, for example: choosing the best from a series of external libraries increases the quality of one's own product; and also allows LMS developers in particular to concentrate on higher-level goals, such as building new tools or interfaces. Berg (2011) also argues that this reuse of code, for which appropriate and consistent solutions have been found and tested actively, saves effort and decreases the complexity of creating new LMS functionalities.

Additionally, Moodle integrates pedagogical features missing in many LMS tools, allowing instructors to construct customizable, online courses or a wide range of course modules on a flexible platform (Lakhan *et al.* 2008). Moodle can be downloaded to any computer and used to support a single instructor site or a system of thousands of students. Many plug-ins are available to enhance existing features. MySQL and PostgreSQL databases can be used with Moodle, and the system is compatible with Oracle, Microsoft SQL Servers and other databases.

Sakai has two versions: Sakai CLE (includes learning management, project and research collaboration and ePortfolios) and Sakai OAE (Open Academic Environment with social and personalization features). Sakai has taken several other open source initiatives under its wing and, as with Moodle, Sakai has diverse community support, and there are companies that offer their own versions and support for Sakai. Among those are Unicorn and rSmart.

#### **2.2.2.2 Other Categorisations of LMSs: Corporate vs. Educational LMSs**

Some literature (mainly non academic literature, for example by McIntosh<sup>10</sup>) broadly categorise LMSs as corporate and educational LMSs. This categorisation is based on the argument that corporate and educational institutions use the LMSs differently, and thus the design features for both categories may be different (Table 2.3).

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<sup>10</sup>[www.trimeritus.com](http://www.trimeritus.com)



Table 2.3: Corporate and educational LMSs features

Features of Corporate LMSs	Features of Educational LMSs
<ul style="list-style-type: none"> <li>• Corporate LMSs usually include registration and management of classroom instruction as well as e-Learning management and delivery</li> <li>• Some corporate LMSs add e-Commerce capability and may include regulatory compliance, competency, performance, human capital and talent management, which link closely to Human Resources functions</li> <li>• Corporate LMSs tend to emphasize the management of asynchronous (self-directed) online learning because there is no assumption that an instructor will always be present</li> <li>• Course authoring and content management are not normally included in a corporate LMS except as part of a suite that includes learning content management (LCMS)</li> </ul>	<ul style="list-style-type: none"> <li>• Educational institutions are usually already well equipped for registration and management of classroom instruction so Education LMSs tend to be primarily for online learning</li> <li>• They usually provide course authoring and some content management features. Consequently they sometimes call themselves LCMSs or Course Management Systems (CMS)</li> <li>• They also emphasize communication and collaboration features.</li> <li>• They are generally built on the assumption that an instructor is always available to build course content and to communicate with students</li> <li>• Most open source LMSs are targeted for this sector</li> </ul>

This categorization of LMSs does seem arbitrary, as there appears to be an overlap between the categories. Furthermore, it also seems to depend more on the way the vendors or developers market their products than on the features themselves. Most open source LMSs tend to be more appropriate for educational institutions than business enterprises.

### 2.2.3 The LMS Ecology

The term ‘ecology’ or ‘ecosystem’ has been used to describe a variety of concepts in information technology (IT), in ICT in education (Reyna, 2011; Gomez *et al.*2013) and in information systems (Nardi *et al.* 1999). According to Reyna (2011), in IT, these terms are mainly used to refer to existing networking infrastructures on the Internet, as used by Chang and West, (2006); Boley and Chang, (2007); Briscoe and De Wilde, (2008); Bo *et al.* (2009); and Briscoe and Marinos, (2009). Reyna (2011) further observes that, in e-learning, the term digital ecosystem (or digital learning ecosystem) has been cited as an ecological model of learning and teaching (Frielick, 2004) and, understanding e-learning infrastructure and implementation (Gütl and Chang, 2008a; Gütl and Chang, 2008b; Uden *et al.* 2007) as well as an aid when designing new learning tools (Ficheman and de Deus Lopes, 2008) and student assessment tools (Gomez *et al.*2013).

The ecological approach can thus also be used to describe the complex interactions between student and interface, student and teacher, student and content, and student and student, which shape learning outcomes. Reyna (2011) argues that, analysis of these interactions is crucial for the in-depth understanding of online learning environments, and to standardise and promote effective e-learning practices.

In information systems, the ecological concept defines a system of people, practices, values and technologies within a particular local environment. According to Nardi *et al.* (1999), in information ecologies, the spotlight is not on technology, but on human activities that are served by the technology. This observation is very useful especially for ICT4D interventions where ICT solutions are designed (or technologies appropriated) to suit the purpose, needs and working environment (context) of the users without having them to adjust their lifestyles or operations in order to benefit from the technology. In the case of this study, the spotlight was on how the students in developing country universities can be able to more effectively and satisfactorily access the services of the LMS using the available ICT infrastructure?

An information ecology perspective of LMS-supported e-learning environments therefore helps us to understand the LMS users and their requirements in a specific context as well the information spaces in terms of the creation and searching of information within the LMS and, delivery and use (consumption) of the information. Information in LMSs is the learning content (or learning objects), which is placed into the LMS by the instructors and accessed (or used) by the students. The creation, delivery and accessibility of the LMS content is very crucial as it requires third party technologies and technological devices through which the LMS services can be accessed. For the LMS to be effectively implemented, the institution, the instructor and the student should be able to effectively access the LMS services. Figure 2.2 below illustrates how the ecological concept brings together the different aspects and user categories of the LMS.

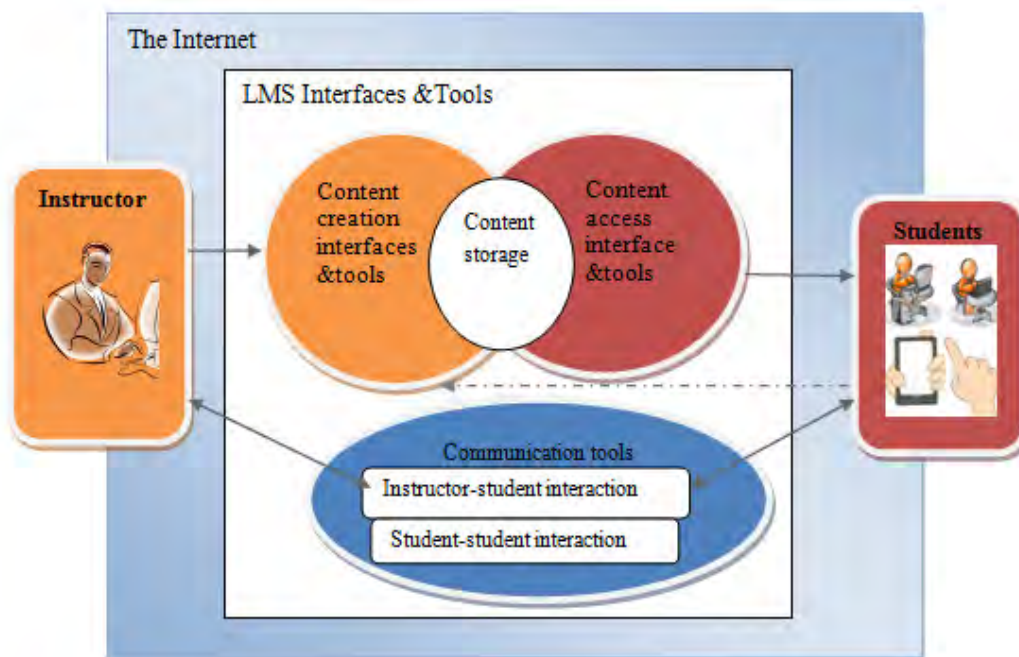


Figure 2.2: LMS ecology

In the LMS ecological diagram shown in Figure 2.2 above, there are two main user categories of the LMS:

- i. The students/learners: These use the system for the educational process. They are the basic or the main users of LMS. They interact with the LMS mainly to access resources that have been made available by the instructors. However, as show by a dashed line form the 'students box' to the 'content creation interfaces and tools', the Web 2.0 characteristics of some LMSs allow students to create some content in the LMS.
- ii. The instructors: The instructors are the teachers, assistants, tutors or administrators who create the LMS content (learning objects) and may use the LMS to supervise, assist and evaluate the learners.

Consequently, as shown in the Figure 2.2, the two user categories appear on opposite sides of the ecological diagram and, the design of LMS interfaces must be seen to accommodate the two user categories who may require to use the different features and tools of the LMS to accomplish different activities. For example, Sharma *et al.* (2013) presents a use case diagram (Figure 2.3) and an activity diagram (Figure 2.4) highlighting some of the interactions and activities expected for the main user categories of the LMS. A use case diagram is a simple representation of a user's interaction with the system and depicts the specifications of a use case. As shown in the LMS ecology diagram in Figure 2.2, Sharma's LMS use case diagram (Figure 2.3) further demonstrates the fact that the instructors (faculty

and admin) and the students appear on opposite sides of the LMS and use different interfaces for interacting with the LMS. The instructors are viewed as information providers while the students' interaction with the LMS is motivated by their need to obtain a service or information from the system. As Yang (2006) and also Jabr (2010) argued, such an arrangement reflects a real world learning scenario in which teachers act as the content producers while students act as the content consumers. However, it should also be noted that the Web 2.0 characteristics of some LMSs allow students to create content, this interaction is also indicated in the ecological diagram in Figure 2.2 above.

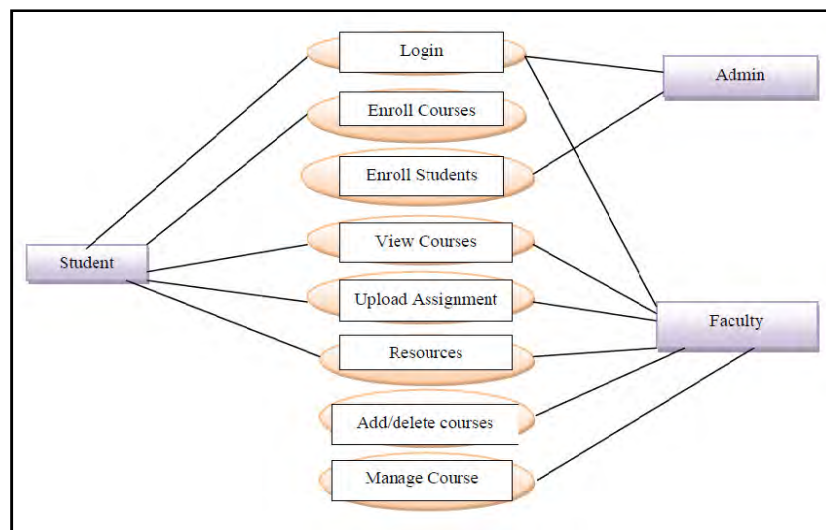


Figure 2.3: User case diagram for the LMS

(Source: Sharma et al. 2013)

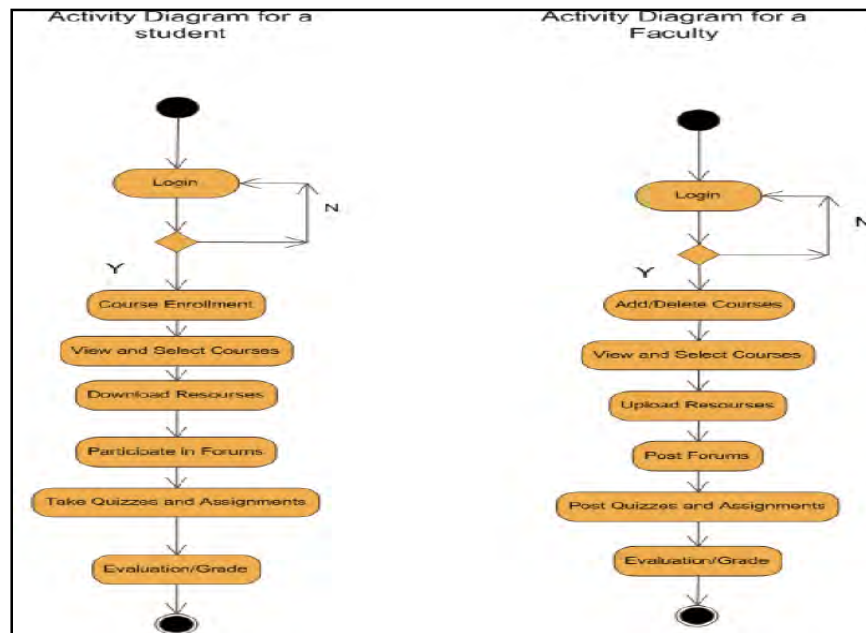


Figure 2.4: Activity diagram of LMS

(Source: Sharma *et al.* 2013)

Figure 2.3, however, shows only a few services of the LMS, yet, as already seen, a typical LMS possesses in excess of 20 different services. It is therefore not clear why and how these particular LMS services in Figure 2.3 were selected. Additionally, it is also not clear why and how the different categories of users are directed to the specific services of the LMS. For instance, after the students have logged-in and enrolled for courses, they should be able to use the LMS to do more than uploading assignments and accessing resources. It would have been more helpful had there been proper justification for the services selected and the flow of activities. This can be achieved through identifying the most commonly used (most needed and most required) LMS services in education institutions by the various user categories, most importantly the students as was done for this study.

### 2.2.3.1 The Creation and Accessibility of LMS Learning Objects

Learning Objects (LOs) represent the smallest components of content within an LMS. Watson *et al.* (2007) define an LO generally as any digital media that can be reused to support learning. Watson *et al.* (2007) reports that earlier work by Gibbons *et al.* (2002) and Hodgins, (2002) showed that LOs can be: reused across multiple contexts; integrated to generate new instructions; adapted to meet the needs of individual learners; and scaled to meet the needs of both larger and smaller audiences without significant changes in cost. A more specific definition of LOs within an LMS is however offered by Leal *et al.* (2011) who

define LOs as units of instructional content that can be used and reused on Web-based e-learning systems. Leal *et al.* (2011) contend that, it is the reusable nature of the LOs that holds the most promise and challenges for LMSs. However, in order to maximize an LO's reusability, it must adhere to the standards such as LRM, IEEE LOM; SCORM; IMS Content Packaging; and IMS Learning Design.

Within the LMS, the LOs are delivered through service components, and the services are created under the different categories of LMS tools. While the precise specifications and service components of LMSs may vary from system to system, a typical LMS provides tools for course administration and pedagogical functions of differing sophistication and potential under four categories: asynchronous and synchronous communication tools; content development and delivery tools; formative and summative assessment tools; and class and user management (Coates *et al.* 2005). Under these tools, there are the different service components. Essentially, a typical LMS such as Sakai, Moodle or Blackboard provides over twenty service components, such as those presented in Table 2.4 through which the LOs are created and presented to the students. Additionally, the modular nature of the current generation of LMSs also means that more service components can be developed independently and added to the LMS as need arises and, within limits, the structures, processes and online appearance of LMSs can be customised (Coates *et al.* 2005).

Table 2.4: Categories of LMS tools and some of the service components of a typical LMS

Tool Category	Service Component	Description/Function
Asynchronous and Synchronous Communication Tools	Announcement	For viewing current, time critical information
	E-mail	For viewing e-mails sent to the site
	Chat room	For real-time conversations in written form
	Instant messaging	Display messages to/from course participants
	Discussion forums	Display forums and topics of the course
Content Development and Delivery Tools	Resources	For accessing documents, URLs or other websites
	Blogs	For course or project blogging or journals
	Slide Show	For showing and viewing slideshows of image collections from resources
	Course outline	For summary outline and/or course requirements
	Podcasts/Vodcasts	For managing individual podcasts/vodcasts and podcasts/codcasts feed information
	News	For displaying news and updates from online sources (RSS feeds)
Formative and Summative Assessment Tools	Assignments	For posting and submitting assignments
	Q&A	For asking and answering questions
	Tests & Quizzes	For taking online tests/quizzes
Class and User Management Tools	Registration & Enrolling	Students registration and course enrolment
	Time Tables	Displaying timetables
	Calendar	For viewing deadlines, events, etc
	Participants	For viewing course participant list
	Polls	For anonymous polls or voting

The LMS service components such as those presented in Table 2.1 above are the ones through which the LOs are presented and accessed by the students. The LOs in the LMS can be created in different forms, such as: plain text, downloadable files, Internet links, pictures, audio clips or video clips. The LMSs have integrated authoring tools that can be used to

create and design the content and deliver it to the students through the LMS services. Du Plessis *et al.* (2005) and Koohang *et al.* (2011) define LMS content delivery and accessibility as the ability of the LOs to be accessed by students in any location regardless of the student experience, device or the type of platform the student uses.

However, ideally, the majority of LMS interfaces are designed for access through devices with wider displays such as desktop and laptop computers which make the navigation relatively easier than on devices with smaller displays, such as mobile phones. Additionally, desktop and laptop computers have relatively greater processing power and larger memory space. However, with the advent of the smart mobile phones, some of which have processing power equivalent to some notebook laptops, the learners are able to access LMS services on their smart mobile phones, though not as well as they would do on the desktop and laptop computers. Mobile phones have limitations such as the small displays, small and limited keyboards and present usability problems due to such limitations. Some studies have been carried out on delivering LMS content on mobile devices. For example, a study by Minović *et al.* (2008) showed that delivering LMS content to the learners through mobile devices did not improve the students' use of the LMS. In this study, students were required to access LMS content on mobile devices using adaptive technologies like Google proxy. The study concluded that possibly the LMS mobile access could be enhanced by the development of rich client applications for mobile devices to improve usability, and that the development of LMS mobile applications needs to have learners at the centre of the development process. This observation was explored in the design, development and evaluation of the mobile LMS interfaces developed in this study.

#### **2.2.3.2 LMS Usability**

The ISO 9241 standard defines usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. According to Costabile *et al.* (2006), Ardito *et al.* (2005) and Wong *et al.* (2003), usability plays a significant role in the success of e-learning applications. If an e-learning application is not usable enough, it obstructs students' learning; the learners would spend more time learning how to use the application rather than learning the content.

Minovic *et al.* (2008) argue that the adoption of the LMS by the students remains low mainly due to poor usability of the LMS. Leal and Queirós (2011) also contend that despite the success in the promotion of the standardization of e-learning systems, usability and



accessibility are still a major user concern with the existing systems. Earlier work by Leal *et al.* (2010) and Dagger *et al.* (2007) claim that adapting Service Oriented Architectures (SOA) to e-learning systems so as to provide flexible learning environments for learners could improve the usability and accessibility of the services. Dagger *et al.* (2007) also argue that the current generation of LMSs embraced a significant development – the “services” principle, exposing certain aspects of their functionality externally. This means that as designs became more modularized, it is easier for platforms to integrate new functionality as it arises. Furthermore, the LMS community has made an increased move towards separating content from tools. However, these systems aren’t entirely learner-centric; they still focus strongly on learning administration (course management) rather than on the learner (Dagger *et al.* 2007).

This study is, however, distinct from prior research, in that the main goal was to enhance accessibility from the point of view of a specific group of LMS users constrained by poor ICT infrastructure, such as electricity outages and slow Internet bandwidth, rather than improving or extending the functionality of LMSs. Similar studies on LMS accessibility were carried out within the framework of the European Commission Web-edu project by Paulsen *et al.* (2003) on the accessibility and satisfaction of LMSs in 113 institutions across 17 European countries. The studies revealed no major technical problems with LMSs, and the users rated accessibility to the LMS services as satisfactory. The studies also noted that in the European Nordic region and North Western Europe where Internet penetration was high, it is not easy to find a university without experiences of LMSs, compared to the Southern European region, where Internet penetration was low. The study concludes that Internet penetration determines the level of use of LMSs.

In developing countries, besides the low Internet penetration, there are other constraints such as power outages and the physical infrastructure such as the local area networks and the lack of enough computers for the learner community. These constraints make it harder for the students to access the LMS services. However, the proliferation of mobile phones in the developing countries has to some extent made up for the generally poor physical ICT infrastructure. This study thus explored the extent to which the mobile phones can be effectively integrated into the LMS ecology to enhance the accessibility of the LMS services and increase the LMS usage by the students.

The integration of mobile phones into the LMS ecology requires creating and developing usable mobile interfaces for accessing LMS services. In order for this to be done, there was

need to understand how mobile applications are developed. The next section presents literature on the state of practice in mobile application development.

## **2.3 State of Practice in Mobile Applications Development**

### **2.3.1 Overview of the Generations and Categorisation of Mobile Phones**

Paananen (2011) presented a critical analysis of the mobile generations from the mobile phone of 1980s to the recently surpassed third generation (3G) of mobile phones (devices). After the first generation, the second generation (or 2G) GSM mobile phones would be used for sending SMS messages in addition to making voice calls. They did not, however, have Web browsers, and did not have any software installation possibilities (Firtman, 2010). All the software was factory installed. Between the second and the third generations, GSM network providers added GPRS, which is a packet oriented data service and the use of the Internet was introduced to the mobile phone, (Fling, 2009). This generation is often described as the 2.5G (Peltomäki, 2010). During this generation, the Web reached the mobile phones. However, using the World Wide Web by mobile browsers remained difficult because of the various limitations, such as the limitations of the devices of that time and the high prices (Fling, 2009; Paananen, 2011).

During the third generation (3G), when 3G mobile networking became widespread, the high speed Internet of the 3G made user experience of mobile Web browsing better and this laid foundation for the smartphone's penetration of the market (Peltomäki, 2010). According to Paananen (2011) a smartphone is an advanced mobile phone with a modern day mobile operating system and advanced hardware features; it is possible to install 3rd party mobile applications to a smartphone and it has an advanced browser and an advanced user interface with a touch screen. Currently, with the fourth generation (4G) mobile phones, ultra-broadband Internet access and high mobility communication are also made available.

Today, mobile devices on the market can be categorised as shown in Table 2.5 below.

Table 2.5: Categories of mobile devices

Mobile Device Category		Features
Basic mobile phones		<ul style="list-style-type: none"> <li>• These are phones with call and SMS support.</li> <li>• They don't have web browsers or connectivity, and they don't have any installation possibilities.</li> </ul>
Feature Phones	Low-end mobile phones	<ul style="list-style-type: none"> <li>• They have web support, typically with a very basic browser</li> <li>• They typically do not have touch support, have limited memory, and include only a very basic camera and a basic music player.</li> </ul>
	Mid- and high-end mobile phones	<ul style="list-style-type: none"> <li>• This is the mass-market option for a decent mobile web experience.</li> <li>• Mid-end devices maintain the balance between a good user experience and moderate cost. In recent years, this category was also known as social devices, meaning that the users access social sites, such as Facebook or Twitter via the mobile web.</li> <li>• In this category, devices typically offer a medium-sized screen, basic HTML-browser support, sometimes 3G, a decent camera, a music player, games, sometimes touch, and application support.</li> <li>• Some of them include wireless LAN (WLAN, also known as WiFi).</li> </ul>
Smartphones		<ul style="list-style-type: none"> <li>• A smartphone, as defined today, has a multitasking identifiable operating system, a modern HTML5 browser, WiFi and 3G connections.</li> <li>• There are dozens of smartphone devices on the market, including iPhone, Android based devices, webOS, Symbian, BlackBerry, and Windows Phone.</li> <li>• Other features : GPS (Global Positioning System) or A-GPS (Assisted Global Positioning System), Digital compass, Video-capable camera, TV out, Bluetooth, Touch support, 3D video acceleration, Accelerometer.</li> <li>• Increasingly viewed as handheld computers rather than as phones, due to their powerful on-board computing capability, capacious memories, and open operating systems that encourage application development.</li> </ul>
Tablets		<p>A tablet is a device with a large screen (between 6 and 11 inches), a full HTML5 browser, WiFi, sometimes 3G, touch support, and all the other features that we can find on a smartphone.</p> <p>In this category, we can find many devices, including the following:</p> <ul style="list-style-type: none"> <li>• Apple iPad</li> <li>• Samsung Galaxy Tab</li> <li>• BlackBerry PlayBook</li> <li>• Barnes and Noble Nook Color</li> <li>• Motorola Xoom</li> <li>• LG Optimus Pad</li> <li>• Amazon Fire</li> <li>• Sony S1 and S2</li> <li>• Etc</li> </ul>

*Sources: Fling, (2009) and Paananen, (2011)*

Although non-smartphones are still actively and effectively used, especially in developing countries, smartphones proliferation is increasing. This is also true for developing countries, especially in academic institutions. A survey that was carried out as part of this study indicated that over 58% of the students in the surveyed universities had smartphones. This

study therefore considered paying more attention to the smartphones for the intervention that was developed.

### **2.3.2 Mobile Application Development Techniques**

In general, there are three mobile application development techniques for smartphones: native application development; Web-based application development and hybrid application development (Douangboupha, 2010).

Native applications are the applications that run locally on the mobile device with the respective platform's programming language (McGuirk *et al.* 2011) and access to the local operating system (OS) and support framework—the native application code is written specifically for a particular phone's operating system.

Web-based mobile applications are applications that render via a Web browser using Web application solutions such as HTML, CSS, JavaScript and other scripting languages. Rajendran (2012) adds that Mobile-Web apps may or may not actually make use of servers running elsewhere across the Web.

A Hybrid application is a combination of a native application and a Web application and runs locally on the mobile device's browser.

Currently, the major smartphone platforms for which the majority of applications are developed include: iOS, Google Android, RIM Blackberry, the Palm OS, Windows Phone and Nokia Symbian (Douangboupha, 2010; Ohrt *et al.* 2012; Wasserman, 2010). To a greater extent, each of the platforms is incompatible with the others and, in turn, the choice of platform limits the choice of tools and languages available to develop its native applications.

In Figure 2.5 below, Doolittle *et al.* (2012) compared the mobile application development techniques as determined by needs and targeted devices. In their comparison, they also included the Virtualized Platform development technique which uses a centralized delivery system (Client-aware cloud as well as platform as a service and software as a service).

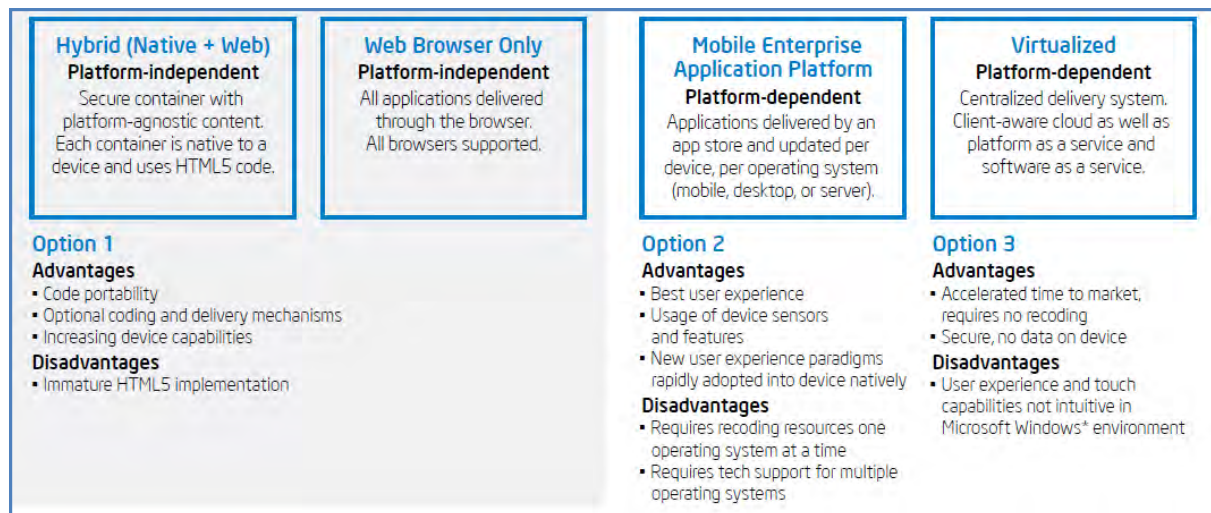


Figure 2.5: Mobile application deployment techniques as determined by needs and targeted devices.

(Source, Doolittle et al. (2012))

Earlier studies by Douangboupha (2010), Paananen (2011) and Rajendran (2012) also compared the merits and demerits of native and Web-based (Cross-platform) mobile application development techniques with the view of analysing which choice is better for different programming needs.

Rajendran (2012) argued that due to the various programming languages and devices, it is almost impossible to write a single version of portable mobile application code that runs on different mobile devices: the production effort in almost the entire software life cycle increases – driving up the cost, lengthening the time to market, and narrowing the target market. This had also earlier been noted by Sambasivan *et al.* (2011). Rajendran (2012) also argues that user interfaces play an essential and significant role in mobile applications. Developers therefore need to take special care in designing the user interfaces. He further notes that most native platforms have wonderful abstractions in common-user interface controls and experiences, but, no two platforms have the same user-interface patterns, let alone APIs to represent and access them. According to Rajendran (2012), native mobile application development presents the following advantages:

- **Device integration:** Mobile device capabilities like camera, accelerometer and network communications can be fully exploited and developers have complete authorization in controlling these services.

- Performance: There is one less layer between the code and its kernel. As a result, the load times and execution speed of native mobile applications are fast.
- Offline capability: Native development permits access to local storage device for offline storage capability and allows developers greater comfort in developing modified storage synchronization.
- Application market integration: Developers can submit the binary distribution file to the application market. Mobile app markets provide distribution and monetization of mobile applications.

Rajendran (2012) further contends that although native application development is still the best in its own way, in the aspect of cross-platform development, native application development has the following several drawbacks.

- Profound platform knowledge: If any application is developed on two or more platforms, developers need to have knowledge of each platform's APIs and programming languages. Developers may not be familiar with two or more programming languages (for example, Objective C for Apple mobile apps, Java for Android and C# for Windows Phone 7). These factors lead to increase in development cost, time and effort. Ultimately, these combined issues become barriers for developers and organizations.
- Limitations in portability: Code developed for one platform could not be easily ported to another platform. The existing code influences any platform specific capabilities. User interfaces vary among platforms. For example, push notification used by Android is not the same as Windows Phone 7. Developers have to write separate code for each platform to support necessary features.

On qualifying the Web-based mobile application technique, Rajendran (2012) concedes that the Web has emerged as a next generation of Internet-based services with the intent to make the Web a platform. The main reason is that the Web has become a significant medium for users to collaborate and share information online by binding collective intelligence (Charland *et al.* 2011). Rajendran (2012) argues that due to the massive availability of information on the Web and rapid growth of mobile devices, the drift of accessing Web-based services has been transferring from desktop computers towards wireless mobile devices. As a result, in many instances, full desktop websites have been optimised to create mobile versions in order to facilitate mobile access. A mobile-optimised website is a website that is intended to be

viewed using a mobile browser on the various display sizes of phones, tablets, and other mobile devices. Mobile websites are typically simplified versions of a standard website that provide a better mobile user experience through improved usability, faster page loads, and sometimes reorganization of content to bring mobile-specific features to the forefront of the experience (Klein, 2012).

In terms of design, development, and deployment, Web-based mobile applications or the mobile-optimised websites are similar to standard websites. Once it is live, it is immediately viewable by anyone who visits the URL with a mobile browser. In addition, despite the technical specification differences between the major mobile platforms, one great commonality is the standards-compliant Web browsers and browser rendering engines which have been inclusively included in the mobile devices by default (Na, 2011; Rajendran, 2012). These eliminate the incompatibilities among mobile browsers, making it easier to develop cross-platform applications. For example, even if Android may run Java and iPhone may be built on objective C, both of them can use a common rendering engine directly to render an HTML application on the screen. After all, mobile Web Apps are simply Web pages, users should therefore be able access them on their mobile devices, using the devices' standard Web browser. Rajendran (2012) presented a diagrammatic representation of the operation of a mobile Web App. This has been re-drawn and presented in Figure 2.6 below.

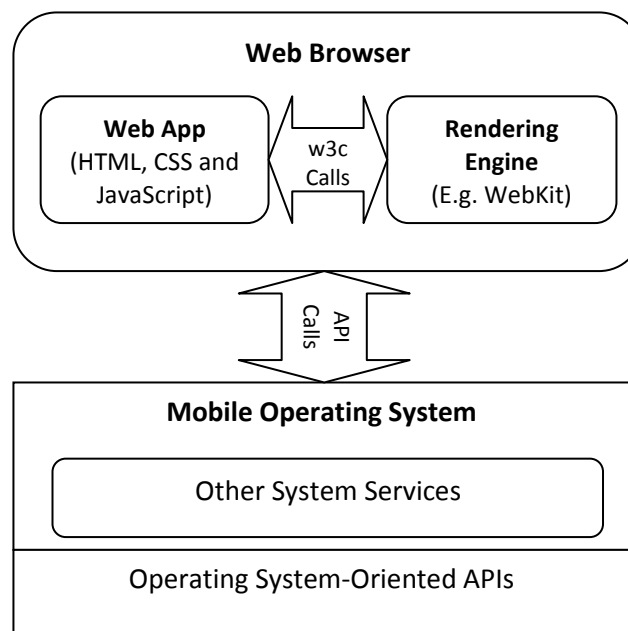


Figure 2.6: Interaction of mobile Web app  
(Re-drawn from: Rajendran, 2012)

As Figure 2.6 above shows, Web applications are mostly comprised of HTML, CSS and JavaScript. These are developed in the Web browser and interact with the rendering engine that provides a set of classes to display Web information, which may be visual, audio or video. A rendering engine renders the Web pages of the application and displays the content. As Rajendran (2012) points out, there are specific sets of APIs to interact with mobile platform system services, as shown in Figure 2.6.

The highlight of Web-based applications is that they can operate across multiple platforms, more so if the Web-based application is developed with HTML 5 support. In terms of security, information is saved in the servers which are in a different (separate) location. Furthermore, a Web application does not need to have an application distribution store as it is available through browser and most application stores deliver that way too. However, as Rajendran (2012) remarks, not all vendors are prepared to give their products away free, and if those products have to be purchased from a special Website, that Website is, in effect, an app store. Rajendran (2012) summarizes the merits and limitations of the Web-based mobile application development techniques as the following:

#### **Merits of Web-based mobile application development techniques**

- Web development skills are enough to create a Web application as the application development demands Web languages. It is quicker to develop a Web app than a native app as the Web application demands the knowledge of Web languages. No in-depth study on platform's SDK and APIs are required.
- Web standards, specifically HTML5, CSS and JavaScript, bring the benefit of the slogan "Write once run anywhere" and the application can operate on native mobile platforms through a device's browser.
- Mobile Web development does not depend on any proprietary SDK licence agreements or any other resources. Web applications can be created by using any text editors.

#### **Limitations of Web-based mobile application development techniques**

- Due to the limited features of HTML5, applications cannot access the native device features completely. The reason is that the application runs within the Web browser and has restrictions in accessing the device APIs (Hussain *et al.* 2011).



- Applications cannot provide a complete support for data-intensive calculations. With an adequately fast Internet connection, data-intensive processing can be moved from client-to server-side devices (Na, 2011). Therefore, Web apps demand a continuous Internet connection and there are applications which operate in offline mode but with certain restrictions.
- Response time is one of the essential parts of the UI interaction: Slow response from the user can be evidence of user confusion, prompting for extra wizards and help. Not only do the Web protocols ignore time, but transmission times across the Web are unpredictable (Rajendran, 2012).
- Compared to native applications, mobile Web applications are likely to have Web-security threats.
- Although HTML 5 has native support for vector graphics, it is difficult for Web app development to provide full support for applications that have 3D features, intense graphics, complex UIs and advanced animated games. It is hard to expect the performance to be similar to native applications.

Douangboupouha (2010) presented a comparison matrix of using the native and the Web-based mobile application development environments (Table 2.6).

Table 2.6: Native Platform versus Cross platform development solutions

	Native	Cross platform
<b>Advantages</b>	<ul style="list-style-type: none"> <li>▪ Library update</li> <li>▪ Direct technical support</li> <li>▪ Size</li> <li>▪ Stable</li> <li>▪ App store and device portal solution</li> <li>▪ Existing UI standard for mobile users</li> <li>▪ Better UI design results, can take full advantage of display</li> </ul>	<ul style="list-style-type: none"> <li>▪ Open Source solutions</li> <li>▪ One programming language family for all</li> <li>▪ Common user interface design could be implemented for multiple OSes</li> <li>▪ Fast development</li> </ul>
<b>Disadvantages</b>	<ul style="list-style-type: none"> <li>▪ Not all have Open Source solutions</li> <li>▪ Different programming languages</li> <li>▪ Different UI design pattern</li> <li>▪ Slow development time</li> </ul>	<ul style="list-style-type: none"> <li>▪ Library update</li> <li>▪ Limited direct technical support</li> <li>▪ Library limited</li> <li>▪ Code size</li> <li>▪ Unstable</li> <li>▪ Not suitable to adapt one UI guideline for all</li> <li>▪ UI design depends on the platform and is limited</li> </ul>

*Source: (Douangboupouha, 2010)*

Paananen (2011) summarizes Douangboupha's matrix in Table 2.6 as:

- Native application programming is the best choice for applications that require stability (enterprise applications, branded applications), performance (games), full API features (applications that use device APIs not found from the cross-platform frameworks), and native look and feel for the application. Furthermore, native mobile application development is worthwhile if the developer has enough financial and time resources available, and the programming skills for the targeted platforms.
- Cross-platform is a good choice if the application uses much Web-based data or shares resources with a website, or it is a lightweight application that does not require much of the smartphone's hardware resources. Cross-platform development is also a good choice if a developer has no native programming skills, the schedule is tight and there is not a great amount of financial resources available for the development.

Ideally, the majority of cross-platform mobile solutions are mobile websites while the native platform mobile solutions are mobile apps. According to Klein (2012), the decision to create either a mobile website or a mobile application depends on: the purpose and goal of the mobile initiative; audience; user experience; ease and speed of implementations; and updates and maintenance, among other considerations. Table 2.7 below gives a comparison between the mobile websites and mobile applications with respect to such considerations.

Table 2.7: Mobile websites vs. mobile apps

Consideration	Mobile Website	Mobile App
Audience reach	Viewable by everyone with a mobile browser	Viewable by individuals with the appropriate device
User experience	Limited by bandwidth, technologies and site performance, but improving	Capable of very robust user experience
Graphics and Effects	Limited by bandwidth, technology, but improving	Superior. Graphics may be stored locally. Effects and animations are limited only by device computing power and memory
Access to hardware functionality	Limited. Device geo location can be utilised	Unlimited access. Camera, Accelerometer, GPS, etc.
Ease of development	Developed with standard Web development tools and technologies	When built for distinct OS and device (native code), unique programming languages and software development kits are required.
Development resources	Build once and deploy for all devices	Built for individual devices and OSes. May require multiple developers with different proficiencies
Development costs	Typically, but not always, less expensive than app development	Typically, but not always, more expensive, especially when multiple devices are OSes are targeted
Ease and speed of implementation	Publish as a website. Immediate availability	May require a submission process. Users must download and install prior to use
Distribution	Viewable with any mobile browser. No distribution is required	Download and installation required
Installation	No installation required. Web-based	Download and installation from website or market place
Updates and maintenance	Easily updated and changes are immediate with browser refresh	iTunes requires a resubmission process. May require multiple development resources if updates are required for multiple devices and OSes
Paid app vs. free app	Difficult. Plus solutions require purchasing ease and confidence associated with iTunes App Store and Android marketplace	Easy to charge for apps, using the available app marketplaces
Search optimisation (SEO)	Can be found through a standard search. Primary website can re-direct to a mobile optimised version when mobile is detected	Typically found through an app store search or linked to from a website
Internet or data connectivity	Required	Can be used offline

*Source: Klein (2012)*

With reference to the comparison between mobile websites and mobile apps presented above, considering the purpose and goal, audience, user experience, ease and speed of implementations, development resources and cost, distribution and updates and maintenance of the mobile solution required for the intervention to be implemented in this study, we

considered a mobile website (cross-platform mobile application) as the most feasible solution. After all, Doolittle et al (2012) also recommended that the choice between mobile application deployment mechanisms (Web-based, native or hybrid) is determined by user needs, ease of implementation as well as the targeted devices.

## **2.4 Integrating Mobile Phones into the LMS Ecology**

### **2.4.1 Theories in Support of Mobile Learning**

As mobile devices increasingly become more ubiquitous and sophisticated, their potential for use in education has created a ‘new paradigm’ (Leung and Chan, 2003). Studies such as those by Ford and Botha (2007), Minovic *et al.* (2008) and Woodill (2010) have shown that due to their unique characteristics such as: portability, social interactivity, context sensitivity, connectivity and individuality, mobile devices have the potential to be integrated into the classroom. As a result, mobile learning (mLearning) has received a lot of critical, theoretical and empirical research attention in recent years (Wright *et al.* 2011).

In theory, mLearning increases access for those who are mobile and, by so doing, mLearning makes education more accessible in that it enables learners to pursue their studies according to their own schedules (Valk *et al.* 2010). The portability attribute of mobile technology also means that mLearning is not bound by fixed class times; it enables learning at all times and in all places, during breaks, before or after shifts, at home, or on the go. In their work Ford and Botha (2007) and Botha *et al.* (2010) proved and concluded that: mobile phones can create an inexpensive, reliable, one-to-one personal learning environment for students; and that Mobile phones proved to be a reliable and convenient technology for communicating essential information to the students, as well as an effective medium for content delivery that reinforced learning and supported student learning activities.

Earlier work by Visser and West (2005) also suggested that mLearning can increase access in those situations where cost represents a significant barrier to learning. They observed that for the individual learner, mobile technology is much less cost-prohibitive than other technologies like personal computers that are necessary for e-learning. Furthermore, Visser and West (2005) also noted that the ubiquity of mobile phones means that educational services can be delivered with learners’ existing resources. Van Weert (2005) also maintained that mobile technology represents an important avenue by which to reduce the gap between

the haves and the have-nots in contemporary society where access to knowledge and information is increasingly important.

With regards to cost, Motlik (2008), Sharples *et al.* (2007), Traxler *et al.* (2005) and Valk *et al.* (2010) argue that the benefit of increased access afforded by mLearning is particularly relevant in the developing country context where many countries are completely bypassing investments in costly, fixed telephone infrastructure for the installation of mobile phone networks. Thus, mobile phones provide a potential way forward for access to educational content for more students, and that many of the students are already familiar with the mobile phone interface to access ICT resources.

More literature on mLearning, such as Keegan, (2002) and Valk *et al.* (2010) also suggests that mLearning broadens the availability of quality education materials through decreased cost and increased flexibility while also enhancing the efficiency and effectiveness of education administration and policy. According to Valk *et al.* (2010), the theories that support the impacts of mobile phones on educational outcomes, as identified in the mLearning literature, can be classified into two broad categories:

- i. Mobiles impact educational outcomes by improving access to education while maintaining the quality of education delivered.
- ii. Mobiles purportedly impact educational outcomes by facilitating alternative learning processes and instructional methods, collectively known as *new learning*.

In their research article titled “*Using Mobile Phones to Improve Educational Outcomes: An Analysis of Evidence from Asia*”, Valk *et al.* (2010) reviewed the evidence of the role of mobile phone-facilitated mLearning in contributing to improved educational outcomes in the developing countries of Asia, by exploring results of six mLearning pilot projects that took place in the Philippines, Mongolia, Thailand, India and Bangladesh. Their findings indicated that although there is much less as to how mobile phones impact educational outcomes by promoting new learning, there is compelling evidence for the developing world that mobile phones impact educational outcomes by facilitating increased access. It is therefore anticipated that integrating mobile phones into the LMS ecology would facilitate increased access of the learning content provisioned through the LMS by the students. Especially for the students in developing country universities, where the LMS access through computers is constrained by other limitations such as power outages.

### **2.4.2 Designing and Developing Mobile LMS Interfaces**

Although mobile phones have desirable characteristics such as: mobility, ubiquity, accessibility, connectivity, context sensitivity, individuality and creativity that would make them ideal for learning purposes, the students still use them reluctantly (or do not use them at all) to access LMS learning content. As revealed by a survey that was carried out as part of this study, mobile phone restrictions such as small screen sizes and limited input mechanisms are always given as the limiting factors for accessing LMS content through mobile phones. Currently, most LMS interfaces are meant for access through devices such as desktop and laptop computers, which have bigger screens, relatively high processing speed and with better keyboards and other input mechanisms. Table 2.8 below presents a comparison of the features of mobile devices and desktop computers which may have to be considered when developing applications for the different devices.

The mobile phone limitations such as those highlighted in Table 2.8 above, limit the use of the mobile phones for LMS access and the majority of LMSs are better accessed through desktop and laptop computers. Consequently, LMSs need to be optimised for mobile access and, in doing so, the design and development of mobile LMS applications needs to take into consideration such mobile phone limitations that pity the mobile phones against desktop and laptop computers for LMS access.

Table 2.8: A comparison of the features of mobile devices and desktop computers for application development

	Mobile	Desktop/Laptop
Memory	Limited	Large Size
Bandwidth	Limited	Higher Bandwidth
Processor Speed	Limited	Significantly faster
Internet Connection	Limited, Wi-Fi, Carrier network dependent (data plan)	Faster speed, Wi-Fi or cable, many network options
Battery	Longer battery hours than most laptops	Constant direct power for desktop
Hardware Features	Limited	Advanced
Screen Size	Small Size	Larger size
Resolution	Low	Mostly high
Keyboard Size	Small Size	Large size
Keyboard Type	Touch screen, virtual keyboard, full QWERTY, character recognition, triple tap	Full QWERTY, Dvorak
Layout	Varies	Few Standards
User and Environment	Mostly mobile, outdoor, unpredictable	Mostly stable, mostly indoor, predictable
Main OS	Android, Symbian OS, Palm Web OS, iPhoneOS, Windows Mobile, RIM BlackBerry and others	Window, Linux, Mac OS, Unix
OS Update	Some phones require device sync with software on a computer	Can be scheduled and can be run in the background
Multitasking	Depends on the OS, limited	Available, advanced
Web Browser	Limited and sometimes OS dependent	Multiple
Most Adopted Browser	Based on WebKit	Internet Explorer, Firefox, Safari, Google Chrome and others
CSS styling for Web Application	Limited and browser dependent	Advanced, and mostly standard across major browsers
Code Size	Should be small and each mobile application catalog has a maximum file size limitation	No limitation
Flash Support	Depends on OS, capability limited	Available and can be manually setup
Multimedia	Limited, depends on OS and devices	Advanced and can be manually setup
User Interface Design	Should follow mobile devices and each OS standard guidelines	One UI could be adopted across different platforms
Distribution	Depends on OS	Free to distribute, and many options are available.

*Source: (Douangboupouha, 2010)*

There have been notable efforts towards the creation of mobile interfaces for the various LMSs. In his study, Shumba (2012) surveyed the visual user interfaces available to the LMS users on mobile devices for some of the most common LMSs and, what the focus of these interfaces was in terms of the kind of tasks they are meant to support the user in accessing the LMS on the mobile phones. Although Shumba's survey was limited by the need for user

credentials to access the full functionality of the systems (as required by implementing universities), and was only able to report on features that are made publicly available by the universities, his findings, some of which are discussed below, give an insight into the understanding of the available mobile LMS interfaces and were useful for this study. The study reported on the available mobile interfaces for Moodle, Blackboard, Sakai, Desire2learn and eCollege.

#### 2.4.2.1 Moodle Mobile Interfaces

There have been a few attempts at making Moodle mobile interfaces, for example Moodle2<sup>11</sup> and the Moodle4iPhones Project. The Moodle2 application interfaces (Figure 2.7) seem to carry all the available Moodle services to the mobile with only a change in the layout as accessed on devices with wider screens such as desktop and laptop computers.

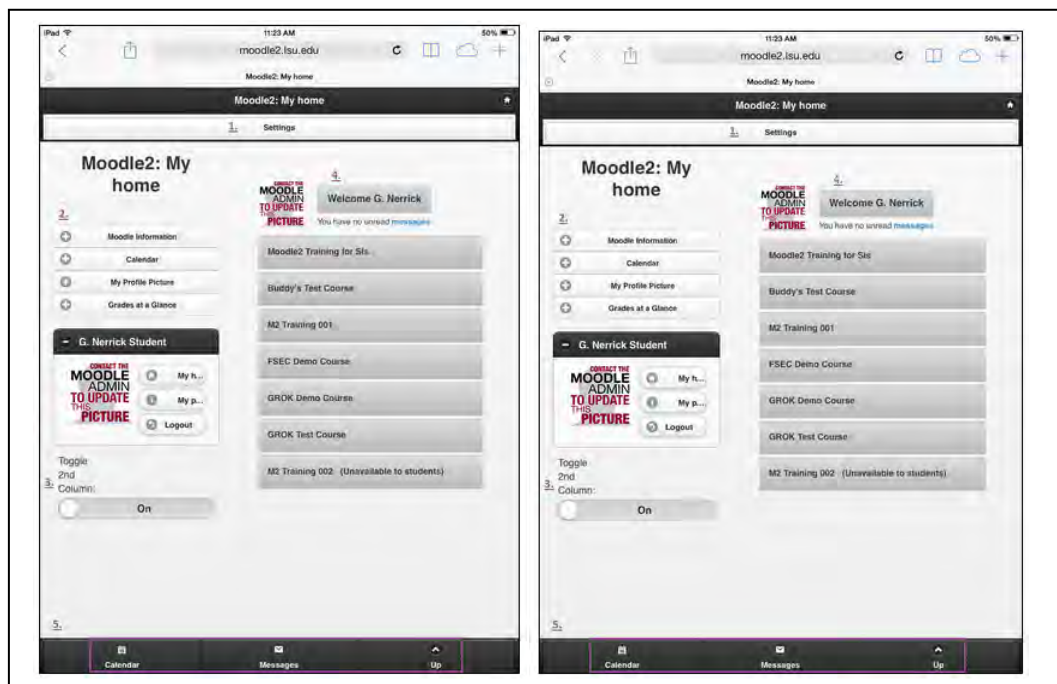


Figure 2.7: Sample screenshots of Moodle2 application interfaces  
(Source <http://Moodle2.grok.lsu.edu/article.aspx?articleid=16419>)

<sup>11</sup> <http://Moodle2.grok.lsu.edu/article.aspx?articleid=16419>



The Moodle4iPhones project is an open source community project aimed at creating a mobile interface for the Moodle system. Sample interfaces are shown in the Figure 2.8 below.

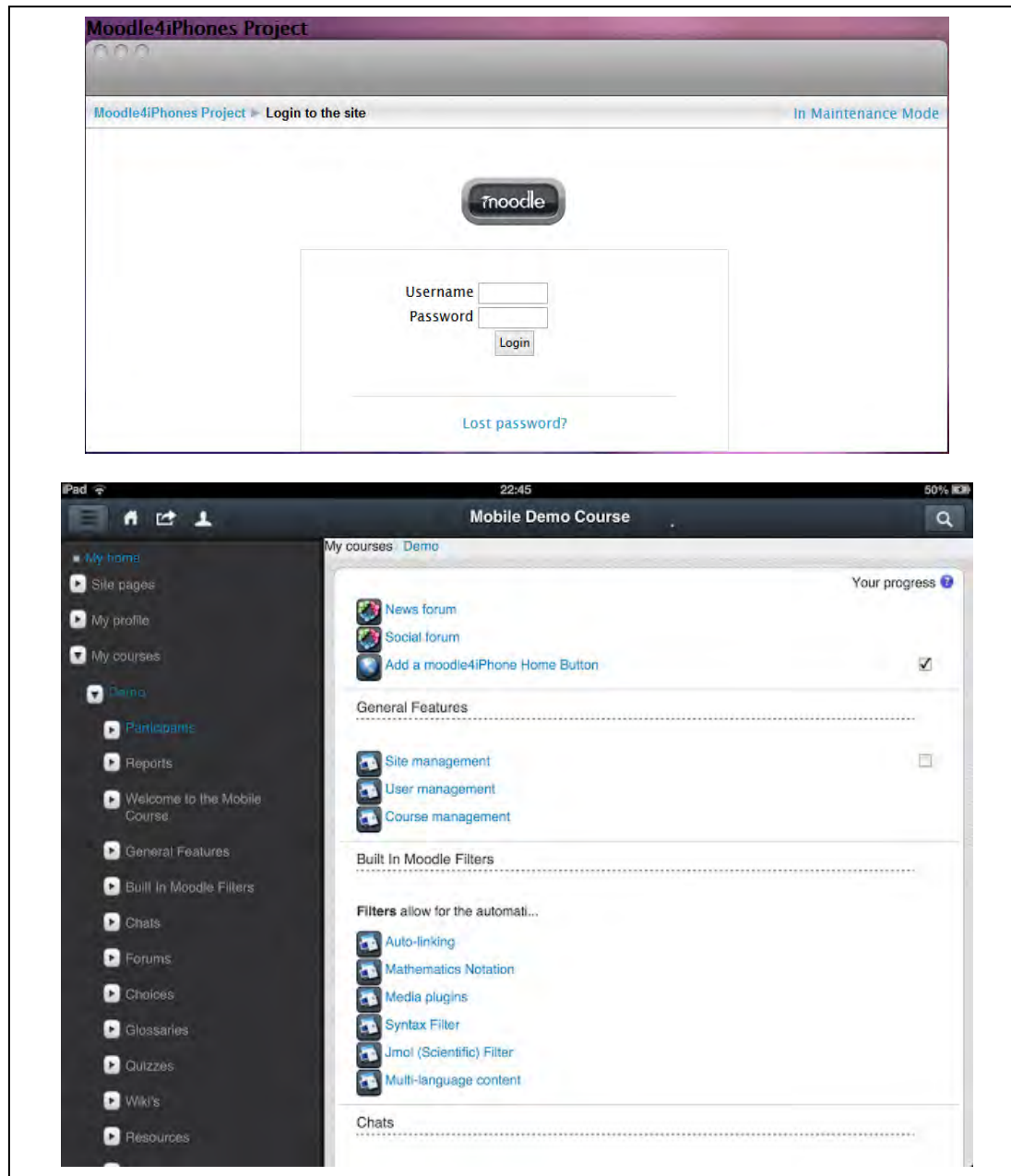


Figure 2.8: Sample screenshots of Moodle4iPhones application interfaces

(Source: <http://iphone.Moodle.com.au/login/index.php>)

The Moodle4iPhones appear to be less congested on the mobile device screen than the Moodle2 application, however, as its name suggests, the Moodle4iPhones only supports the iOS platform.

#### **2.4.2.2     *Blackboard Mobile Learn Interfaces***

Blackboard's official mobile application is called the Blackboard mobile learn app. The application provides students and instructors with access to their Blackboard courses and content using their smart phone, iPod or iPad. Blackboard being a proprietary platform, this mobile application is available to users through an app store at a fee, which restricts its use. According to the Chabot College<sup>12</sup> (portal), a Blackboard-implementing institution, the Blackboard mobile learn app is currently available for a variety of Smartphone devices including Android and iPhone devices, and the App can be used via Wi-Fi or the user's provider's network connection (3G/4G). The app also boasts a new feature of push notifications for new content, announcements or grades. Figure 2.9 below shows some screenshots of the Blackboard mobile learn app interfaces.

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<sup>12</sup><http://www.chabotcollege.edu/online/mobilelearn/>



Figure 2.9: Sample screenshots of Blackboard mobile learn app interfaces.  
 (Source: <http://www.chabotcollege.edu/online/mobilelearn/>)

The interfaces of Blackboard mobile learn app shown in Figure 2.9 appear not to be congested on the mobile device screen. It appears that only a few services out of the many services provided by Blackboard LMS are provisioned through the mobile devices. This feature was explored and probed in the intervention that was developed for this study.

### 2.4.2.3 Desire2Learn Mobile Interfaces

The Desire2learn LMS has developed a mobile Web application for accessing the LMS content on the mobile phones. The application is called 'Desire2learn 2Go'. Desire2Learn 2GO Mobile Web has an interface optimized for mobile Web browsing and is part of Desire2Learn learning environment. Figure 2.10 below shows screenshots of the Desire2Learn 2GO Mobile Web application.

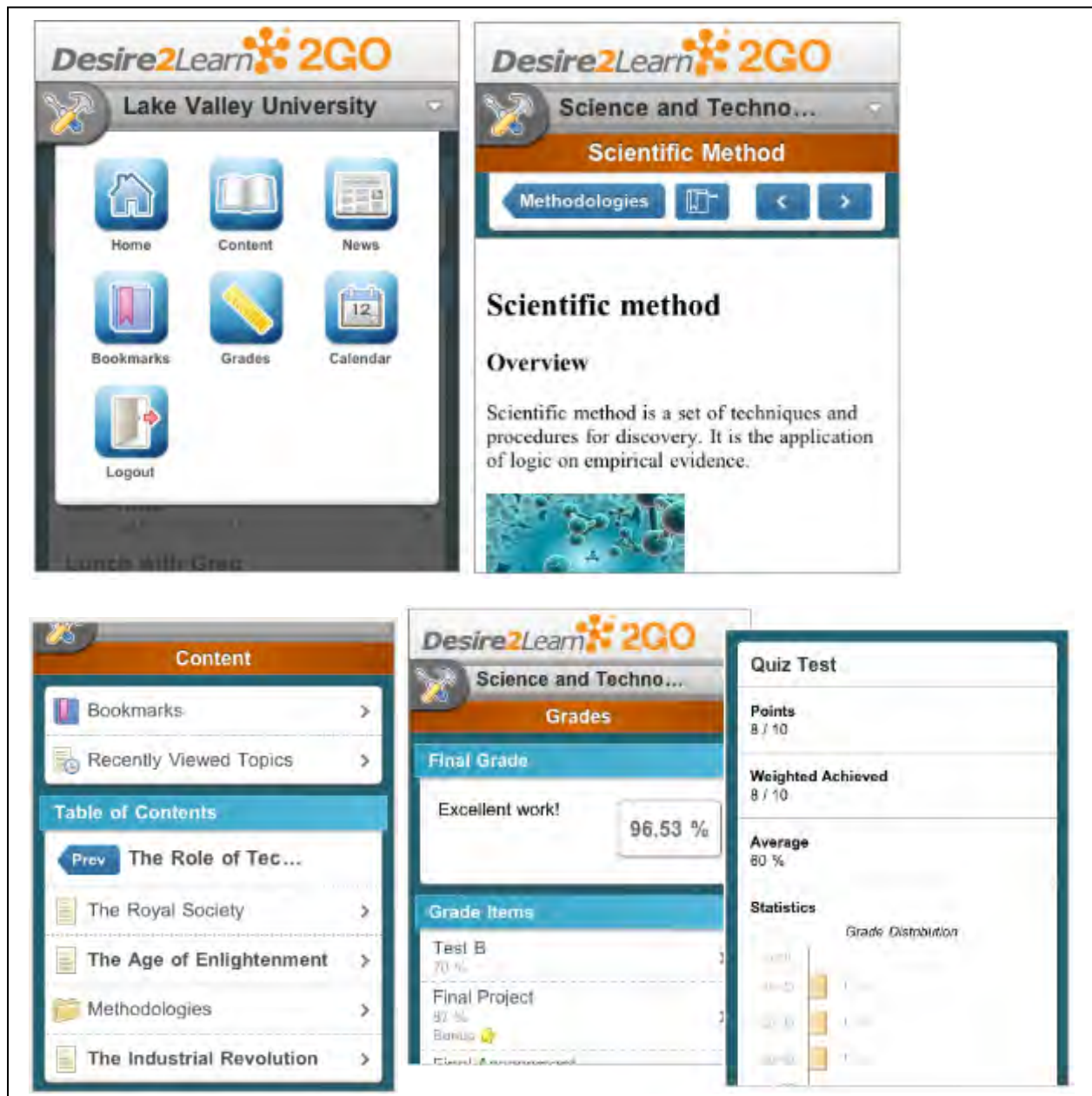


Figure 2.10: Sample screenshots of the Desire2Learn 2GO mobile Web application interfaces.

(Source: [http://oit.drake.edu/wp-content/uploads/2011/04/Desire2Learn\\_2GO\\_For\\_Mobile\\_Learning.pdf](http://oit.drake.edu/wp-content/uploads/2011/04/Desire2Learn_2GO_For_Mobile_Learning.pdf))

The Desire2learn 2Go interface is an optimized version of the Desire2learn interfaces to fit the small screen of the mobile phones. However, there doesn't seem to be a significant difference in the designs and lay out of the interfaces for Desire2learn 2Go from the full Desire2learn LMS meant for access on the desktop and laptop computers.

#### 2.4.2.4 Sakai Mobile Portal Interfaces

The Sakai LMS has a portal for mobile devices. The portal transforms the data for a small screen: it flattens the tool/site hierarchy so that they can coexist in the same location; serves up a frameless experience and it removes many elements from the portal that would be noise in a small screen. AS Sakai is an open source platform, much of the support of the LMS mobile portal relies on community based projects. Consequently, as Watermeyer (2012) states, the efforts of creating and developing finished interfaces relies on scattered individual institutions with little coordination and collaboration. However, since 2011, the Universities of Cambridge, Florida, Indiana and Oxford have proposed the establishment of a “Mobile Sakai” collaborative project to expand upon current, limited mobile functionality, build upon current work in progress, and to develop frameworks usable by local institutions to integrate Sakai into their own mobile initiatives (Mobile Sakai, 2011). To-date, this is a work in progress. Figure 2.11 below shows screenshots of the current Sakai mobile portal application interfaces.

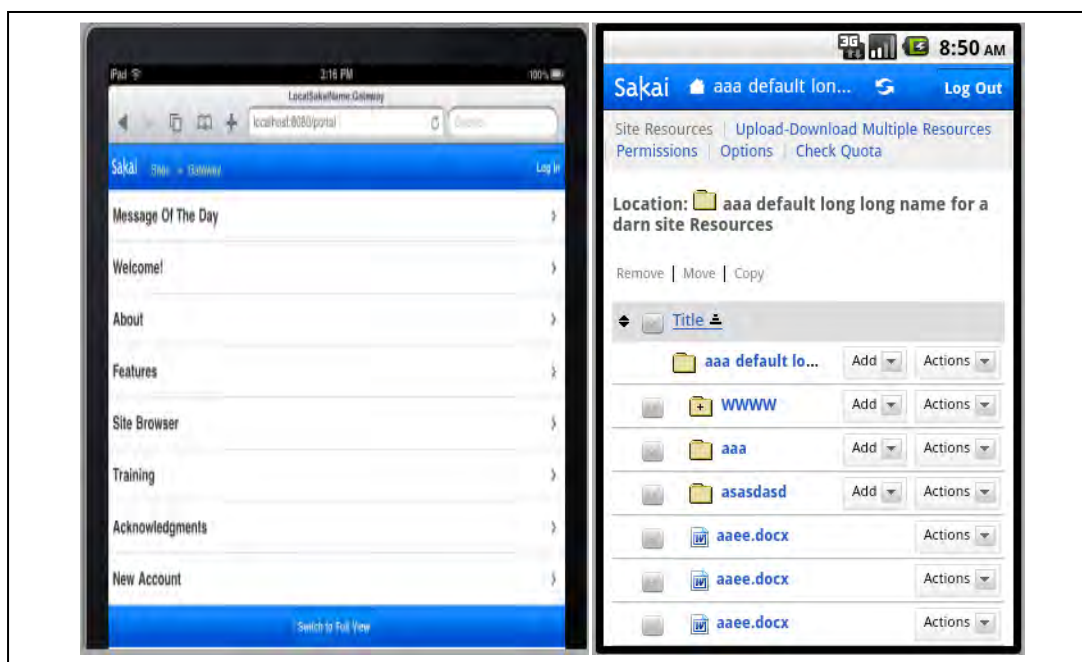


Figure 2.11: Screenshots of the Sakai mobile portal application interfaces.  
(Source: <http://gonzalosilverio.wordpress.com/2010/12/09/sakai-mobile-portal/>)

The current Sakai mobile portal application does transform the data into a small screen, but the interfaces look similar to the full screen desktop interfaces and are not quite usable (Shumba, 2012) to compel the students to use their mobile phones to access the LMS. Shumba (2012) proposed and designed mobile interfaces for Sakai. However there was no investigation done to identify the requirements of the students prior to the designs. The project was also not evaluated for usability through the standard procedures and its impact was not assessed.

Literature also reveals other studies that have been done on LMS mobile access. For example, a study by Minović *et al.* (2008) showed that delivering LMS content to learners through mobile devices did not improve the students' use of the LMS. In this study, students were required to access LMS content on mobile devices using adaptive technologies like Google proxy. The study concluded that possibly LMS mobile access could be enhanced by the development of rich client applications for mobile devices to improve usability, and that the development of LMS mobile applications needs to have learners at the centre of the development process.

### **2.4.3 Gaps in the Reviewed Efforts Towards LMS Mobile Interface Design and Development**

Firstly, most of the mobile LMS portals reviewed here have been designed with the goal of making the LMS functional on mobile devices with small screens. However, the designs seem to have overlooked the issues of usability which are of greater importance to users. As Shumba (2012) argues, the concept of a mobile LMS is to extend the current functionality of the LMS and provide users with a system that allows them to access course information using a mobile device.

Secondly, most of the reviewed systems are naive in that they simply move desktop layouts to mobile, a practice that had been condemned in HCI literature (Jones and Marsden, 2006; Fling 2009; Nielson 2012).

Thirdly, most of the attempts to improve mobile LMS experience have all required platform specific hardware, which is too limiting and too hard for institutions in the developing world to implement. This study thus explored the possibility of creating a cross-platform application for usable mobile LMS experience.

Finally, most of the attempts did not involve the stakeholders in mapping out the problem space and during the design and development process of the solutions, yet, as argued by

Petrelli *et al.* (2005); Hadjerrouit (2010); Murphy (2004) and Penna *et al.* (2007), considering users at all stages is key to designing usable applications, as it compels designers to think in terms of utility and usability and helps develop the system to focus for what is actually needed.

## **2.5 Summary**

Having reviewed literature on: the nature and use of LMSs; the state of practice of mobile application development; and the various efforts towards creating mobile LMS interface so as to integrate mobile phones into the LMS ecology, this study identified gaps in the current efforts, as noted above. Notable are that: some designs simply moved desktop layouts to mobile while others were platform specific and so limited to a few users. The users (especially the students) were also fully involved in the majority of the efforts.

This study therefore considered fully involving the users right from the process of identifying the constraints leading to the limited use of the LMSs in developing country universities, the LMS use requirements, to the subsequent design, development implementation and evaluation of the identified intervention.

The next chapter presents and analyses the findings of the surveys that were carried out to investigate the use and limitations of LMSs in developing country universities. These findings together with a critical reflection on the reviewed literature, including the various best practices and shortfalls identified through the literature were used to design, develop, implement and evaluate the intervention.



## CHAPTER 3: STUDYING THE USE AND LIMITATIONS OF LMSs IN DEVELOPING COUNTRY UNIVERSITIES

### 3.1 Introduction

This chapter reports on and discusses the findings of the two surveys that were carried out in this study to investigate the status of LMS implementation, limitations and students' use and expectations of LMSs in developing country universities, with a view to identifying strategies for more successful implementation the LMSs. The first survey was carried out in five universities to investigate the current status of LMS implementation in developing country universities. The findings from this survey were useful in answering research question (i), which is, '*what is the current status of LMS implementation in developing country universities?*' and to inform further research towards the likely intervention(s) for more successful implementation of the LMSs in developing country universities. Many of the findings of this survey have appeared in the paper titled "*Issues of Adoption: Have E-Learning Management Systems fulfilled their Potential in Developing Countries?*"(Ssekakubo *et al.* 2011).

The second survey was carried out to probe the students' use, experiences and expectations of LMSs so as to identify strategies of enabling better access to the LMS services by the students. The survey set out to: investigate how the students are currently accessing LMS services; identify the LMS services that are most needed and desired by students; and to identify appropriate access strategies that would guide design decisions on how to enable the students to access such LMS services more satisfactorily using the available ICTs and ICT infrastructure, notably the mobile phones. The findings of this survey were useful in answering research question (ii), which is, '*what services of the LMS are more needed and desired by the learners in developing country universities?*' Most of the findings this survey appeared in the paper titled "*Learning Management Systems: Understanding the Expectations of Learners in Developing Countries*" (Ssekakubo *et al.* 2012) and a journal article titled "*Designing Mobile LMS Interfaces: Learners' Expectations and Experiences*" (Ssekakubo *et al.* 2013). The findings were also useful in designing the intervention that was implemented and evaluated in this study.



The chapter contains two sections: the first section (Section 3.2) presents the findings of the first survey in which the factors that are limiting more successful implementation LMSs were identified; and the second section (Section 3.3) presents the findings of the second survey in which the students' use, experiences and expectations of the LMSs were investigated.

### **3.2 Survey to Investigate the Limitations of LMSs in Developing Country Universities**

This survey was descriptive in nature, and was carried out through semi-structured interviews over the telephone. The telephone survey allowed the interviewer (the researcher) the opportunity for some opinion probing (Walonick, 2010) through in-depth interviews, which were based on a common interview guide. The interviews were recorded and thereafter the data was transcribed and thematically analyzed. This method of data collection was adopted from a similar study that was carried out within the framework of the European Web-edu project that analyzed the experiences of European institutions with learning management systems (Paulsen, 2003). Other studies such as Chih-Cheng *et al.* (2011), Walonick, (2010), Gibson *et al.* (2004) and Welsh (2003) also point out that such a method of data collection is ideal when the sample comes from a wide geographical area, as was the case for this study. Five (5) interviewees from five (5) universities in four (4) African countries participated in this survey.

The five (5) universities that participated in this survey were selected from four (4) developing countries, in East and Southern Africa. These were selected on the basis of: evidence of e-learning activities in the university, especially related to the use of learning management systems; and the likelihoodness of getting a contact person in the university/country, who would then help in the identification of the survey respondent(s).

Information on the universities' e-learning activities was obtained from the universities' websites and, in addition, a list of universities in Africa<sup>13</sup> provided a picture of ICT situations in academic institutions and was very useful in verifying and cross-checking with the information provided on the universities' websites.

The respondents to the survey were the key e-learning personalities (e-learning coordinators, e-learning team leaders, e-learning managers and educational technology directors) from the selected universities. These were identified and introduced to the researcher by the country

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<sup>13</sup>Available at: <http://www.chem.ru.ac.za/afuniv.html> Accessed on 20/03/2011

contact persons who were mainly members of staff in the selected universities, and were at the time graduate students/researchers at the University of Cape Town. The participating universities were originally selected from Kenya, Uganda, Mozambique, Zambia and South Africa. However, due to a communications breakdown with the contact person from Mozambique, the university from Mozambique was dropped from the study. This led to a choice of two universities from one of the four remaining countries. The final list of participating universities was: Makerere University (Uganda); University of Nairobi (Kenya); University of Zambia (Zambia); Nelson Mandela Metropolitan University (South Africa); and University of Cape Town (South Africa).

The identified respondents (the key e-learning personalities in the selected universities) were first contacted by telephone, and upon their acceptance to take part in the survey, a semi-structured interview guide (Appendix 3.1) was sent to them through e-mail. Then telephone interviews were arranged with each of them at their convenience. Skype<sup>14</sup> was used where possible.

The findings of the survey highlighted some of the major constraints that are responsible for the limited success of LMS implementation in developing country universities, as well as an overview of the status of ICT infrastructure with respect to the support of LMS implementation in the surveyed universities. The findings indicated that, while the universities had varying success/failure experiences at various levels/stages of LMS implementations, they generally faced similar challenges, and these ranged from resource constraints to infrastructural and technical challenges. The next sub sections 3.2.1 and 3.2.2 present and discuss the LMS implementation experiences for each of the surveyed universities and the factors that were identified as the major barriers for the more successful implementation of LMSs.

### **3.2.1 LMS Implementation Experiences in the Surveyed Universities**

#### ***3.2.1.1 Makerere University***

Makerere University was found to have implemented three different LMS-supported e-learning initiatives in the previous 10 years, all yielding minimal success: Blackboard, Kewl<sup>15</sup> and Moodle. Blackboard was the first LMS to be implemented by the University in 2002. The initiative was supported by a collaboration funded by the Netherlands organisation for

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<sup>14</sup> Skype's ability to easily record conversations for later analysis made it ideal for this survey. <http://labnol.blogspot.com/2006/06/how-to-record-skype-conversations.html>. (Accessed 30/03/2011)

<sup>15</sup><http://www.kewl.uwc.ac.za>

international cooperation in higher education (NUFFIC). The University used Blackboard for three years, and the success of the initiative was limited by a number of factors, as explained by the University's e-learning manager. At the end of the donor funding, the University stopped using Blackboard because they did not have enough resources to continue paying the license fees. The University then moved to Kewl. Being an open source LMS, Kewl provided hope for sustainability. However, less than two years later, with very little success with Kewl, the university decided to stop using Kewl, citing usability problems with the LMS. They then moved on to Moodle, another open source platform. Moodle has now been customized and branded MUELE<sup>16</sup> (Makerere University E-Learning Environment). However, according to the e-learning manager of the university, MUELE is yet also to be utilized to its potential, and he attributes the limited usage of the system to constrained ICT infrastructure (which limits the students' accessibility to the LMS services), among other challenges.

As Makerere is currently one of the best resourced universities in Uganda, it is likely that similar trends in LMS-supported e-learning initiatives, or even worse, are experienced in the other universities in the country, and most probably across the region.

### ***3.2.1.2 University of Nairobi***

At the University of Nairobi, three different learning management systems had been implemented in the past five years (by the time of this research). These were: Wedusoft<sup>17</sup>, Chisimba<sup>18</sup> and Claroline<sup>19</sup>. Wedusoft was specifically developed by a member of staff for the University while Chisimba was adopted and implemented through collaboration with development partners. Both Wedusoft and Chisimba LMSs did not have much success at the University. At the time of this research, the University had implemented Claroline, an open source LMS, but its usage was described as minimal. According to the e-learning coordinator at the university, the e-learning initiatives in general, and LMSs in particular, were frustrated by a host of factors, including ICT infrastructural constraints and the lack of motivation for the resource persons to create online learning materials, among others. The e-learning coordinator received consistent complaints from the resource persons (staff) that even if they made learning materials available online, the students never accessed them.

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<sup>16</sup>[www.muele.mak.ac.ug](http://www.muele.mak.ac.ug)

<sup>17</sup><http://elearning.uonbi.ac.ke>

<sup>18</sup><http://www.chisimba.com>

<sup>19</sup><http://www.claroline.net>

### ***3.2.1.3 University of Zambia***

By the time of this research, the University of Zambia had implemented two learning management systems: Moodle and CMAP. CMAP was specifically used for its Cisco programme only. With Moodle implemented university-wide, the university hoped to de-congest classrooms, conduct distance learning and reduce training costs by re-using training materials provided on Moodle. However, according to the e-learning coordinator, none of these objectives has been achieved, mainly because the students' access to the LMS services was limited by the few computers at the university, and yet the majority of the students did have personal computers or laptops. The few computers at the university were also not well-maintained, and Internet connectivity was described as not 'good enough' most of the time.

### ***3.2.1.4 Nelson Mandela Metropolitan University***

At Nelson Mandela Metropolitan University (NMMU), Share-point<sup>20</sup>, a Microsoft content and document management system was used as the LMS, to make courses available for sharing and collaboration in a blended environment. However, the platform was found to be less flexible, and had limited interactivity options. By the time of this research, Share-point was being gradually replaced by Moodle. Moodle was first implemented by individual lecturers in the Faculty of Education and was gradually spreading out through organic growth to the rest of the University. However, NMMU also contends that Moodle may still not be the ultimate answer to the university's e-learning requirements, as they were yet to evaluate it.

### ***3.2.1.5 University of Cape Town***

At the University of Cape Town, Sakai, an open source platform, is currently being used as the major learning management system. Sakai at UCT has been customized, and locally branded 'Vula', and its implementation has been described as 'quite successful'. In the past, the University has also deployed other LMSs such as WebCT. The turnover of the LMSs at the University has resulted in data migration difficulties and created frustrations among the user communities. However, it was described as necessary because the University had to continue seeking an LMS that would satisfy most of their needs, that is: an interoperable system that would integrate well with their existing systems; flexible and adaptable to changing pedagogical needs; cost effective, easy to support and easy to use; and both scalable and sustainable.

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<sup>20</sup><http://www.sharepointlms.com>

### **3.2.2 Factors Limiting More Successful LMS Implementation of LMSs the Surveyed Universities**

The common themes, or the factors that were identified by the key e-learning personalities in the surveyed universities, as being responsible for the limited success of LMS-supported e-learning initiatives in their universities were extracted and are presented and discussed below.

#### ***3.2.2.1 Poor Internet Connectivity and Electricity Outages***

Although all the universities that were surveyed had Internet connectivity, the quality of the Internet connectivity (low Internet bandwidth) is still a major constraint in the majority of the universities. This finding is consistent with Aluoch (2006), who noted that connectivity in Africa is: poor; unreliable; scarce and very expensive; where available, it is almost never dedicated; and users have to contend with frequent service outages at very slow speeds. Alemneh (2006) also pointed out that the spread of the Internet in African higher education cannot be considered in isolation from the development of the Internet on the continent as a whole. However, from the time Aluoch published his research, the situation in Africa has improved relatively; the introduction of new optic fibre technology and 3G mobile technology has generally improved Internet access in Africa, especially in cities and towns. These can probably be taken advantage of in enhancing the implementation of LMSs in academic institutions.

Electricity supply in most of the universities is unreliable. Some universities resort to diesel-propelled generators to keep the Internet servers (services) running, but they cannot support the students' laboratories on such generators because they are expensive (unsustainable) and environmentally unfriendly. This means that the computer laboratories have to remain closed for long hours due to electricity outages, which makes it very difficult for the students, most of whom depend on the university facilities to access online resources or even engage in e-learning.

#### ***3.2.2.2 Knowledge gap among the LMS Users***

A knowledge gap exists among the three e-learning stakeholders (students, teachers and the administrators). Through this study it was noted that during the deployment of LMSs in universities, the teachers and managers usually received user training, while the students (demand/consumption side) were often left out as far as user training is concerned. Four out of the five universities noted this concern. This has also been evidenced in literature. For

example, in their e-learning guide, “*Facilitating Online*”, Carr *et al.* (2009) developed an online facilitation course, as an Open Educational Resource for training educators and online community facilitators but the students were not given due attention. Generally, as new e-learning technologies are adopted, attention has mostly been focused on the supply side (teachers and institutions) with less attention to the consumption (students) side. Yet, as also noted by Khan *et al.* (2010), for any society at the nascent stage of ICT application, it is crucial to identify and provide skills needed from the users’ (demand/consumption) side. Hameed *et al.* (2009) also asserted that it is important for the teachers and the institution to address any issues to satisfy the third group of stakeholders (students) before deploying any virtual learning environment: “No matter how good the e-learning environment is and what best technology is used to create it, if students cannot access it, then it is of little use”. Also according to Shahid (2005), a responsive student community is crucial if e-learning is to succeed.

#### ***3.2.2.3 Limited ICT Infrastructure and few Computers***

In the majority of the universities surveyed, ICT infrastructure such as: hardware of the local area networks, wireless networks, and the computer labs were said to be a major constraint and a barrier to the students’ access of the LMS services. Compared to the student populations in these universities, the computer labs and computers were insufficient to satisfy the demand and the students’ requirements. The available infrastructure was over-used, leading to wear and tear and constant break-down of the computers. The student to computer ratio was reported to be very high, and the majority of the students were reported to depend entirely on the institutional computers for accessing learning materials. This finding was consistent with Alemneh (2006), who noted that most African universities do not have sufficient infrastructure to utilize digital resources.

#### ***3.2.2.4 Low ICT-literacy Rates and low Comfort Levels Using ICT-solutions***

The respondents from three of the universities that were surveyed echoed the fact that the majority of the students in their universities have not been exposed to many ICT solutions. Consequently, their confidence and comfort levels while using such ICT solutions are always low. The low ICT-literacy rates and the low comfort levels with technological solutions have led to slow acceptance and use of LMSs by the student communities in the developing countries.

This finding was consistent with Tijdens *et al.* (2005) who observed that there is a strong correlation between adaptability to new ICT solutions and the intensity of ICT use.

### **3.2.2.5 LMS Selection and LMS Usability Issues**

It was also noted that, while the selection criteria of the LMSs by the universities has always been based on many factors, usability of the LMSs has rarely been one of the factors. The decisions to adopt some LMSs in some of the universities surveyed have been directives from top university managers with little or no technical input at all. Below are some of the direct quotes from the respondents:

*“We took on our previous LMS because it was open source so we were not required to pay license fees, and yet again we were promised technical support from the proprietors”*

*“Taking on this LMS was a decision agreed upon between our development partners and top university managers”*

The respondents further revealed that in some cases the usability assessment of LMSs was not done due to the unclear and/or costly criteria of performing the evaluation. Some of the universities that were restricted by such constraints evaluated the LMSs by modelling themselves on other universities (mostly in the developed countries) where such LMSs had been deployed successfully, although it was highly unlikely that the operating conditions in such universities were comparable. Yet, usability, by definition, emphasizes the use of a product by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Ardito, 2005). Below is a direct quote from one of the respondents:

*“We did not have resources at the time to evaluate the LMS for usability, more so we were convinced it would work for us because it had been proven successful at the Proprietary University.*

As described by Ludvine *et al.* (2009) and Minović *et al.* (2008), if LMS usability problems are not identified and addressed, they cause disappointments and frustrations during learning, leading to poor perceptions towards the LMS among the student communities. Eventually the students may stop using the system, especially if there are alternative ways to learn, such as the face-to-face sessions. This was the case with two LMSs in the universities surveyed.

### **3.2.2.6 Ineffective Maintenance and Inefficient User Support Strategies**

For the LMS-supported e-learning initiatives, maintenance and user support are very crucial as it is the mechanism through which inefficiencies and other usability problems of the LMS can be identified and addressed. Unfortunately, however, three out of the five universities surveyed did not have proper maintenance strategies, which resulted in deterioration of the LMS services. One of the universities did not even have a technical unit to offer support to the users, while those that had were reported as either understaffed or insufficiently trained to be able to deal with the task at the level required. One responded said:

*“...the department of computer science helped in the initial installation of the LMS server, but the day-to-day technical support and maintenance is not binding on to them, so the technical support is mainly through ‘peer-2-peer help’.”*

### **3.2.2.7 High Expectations and Poor Marketing Strategies**

Through this study it was noted that the goals set by most developing country universities for the e-learning initiatives are usually ambiguous and to some extent very ambitious. It was therefore always difficult to monitor the progress and measure the impact of the initiatives so that timely interventions could be instigated where necessary.

## **3.2.3 Summary of the Survey Findings**

Section 3.2 of this chapter has reported the findings of the survey that was carried out to investigate the current status of LMS implementation in developing country universities. These findings were useful in answering research question (i). Five Universities were surveyed and, the more successful LMS implementation in these universities was found to be limited by a number of factors including: poor Internet connectivity and electricity outages; knowledge gap among the LMS users; limited ICT infrastructure and few computers; low ICT-literacy rates and low comfort levels using ICT-solutions; LMS selection and usability issues; ineffective maintenance and inefficient user support strategies; and high expectations and poor marketing strategies, in addition to the unique challenges faced by the individual institutions. In the majority of the universities that were surveyed, LMSs were deployed with the hope of reducing training costs and improving the quality of teaching and learning through enhanced accessibility to the learning resources by the students. However, to a larger extent, this was not achieved by the majority of the universities due to the above limiting factors.



Overall, from the survey, it was noted that the limited success of LMS-supported e-learning initiatives in most of the surveyed universities had little to do with the LMSs themselves, and more to do with institutional constraints and how the institutions are using the LMSs to improve, support and facilitate student learning. Thus, the high turn-over of LMSs in institutions that are searching for the most appropriate system may not be justifiable; instead, the institution may run the risk of diverting the meager resources into managing transitions. However, given that a stable learning management system can be a prerequisite for making advances in e-learning, if the LMS has adverse usability problems, is not stable, or suffers from performance or up-time failures, then such change may be unavoidable.

In the majority of the surveyed universities, ICT infrastructural related constraints, power outages and internet bandwidth were found to be the major barrier to the more successful implementation of the LMSs. In cases of power outages, while some universities could afford to keep the servers running on generators/solar, the generator power could not support the students' computer labs. This meant that the LMS content remained largely unaccessed and therefore unused by the students. The instructors were de-motivated to continue creating and uploading learning content and information into the LMSs since these were not accessed by the intended users (the students). As a result, the LMSs were abandoned.

For the LMSs to be more successfully implemented in the developing country universities therefore, there was need to seek solutions to reduce the impact of the ICT infrastructural constraints. Notably the need to seek ways of using the available ICTs and ICT infrastructure to improve the students' access to the LMS services. For example by enabling access of the LMS services through mobile phones, after all, the mobile phones do not entirely depend on the institutional ICT infrastructure for accessing the LMS services, and they do not require constant supply of electricity.

In a subsequent survey, the use, expectations and experiences of the students with LMSs were explored. The process and the findings of the survey are reported in the next section (Section 3.3).

### **3.3 Survey to Investigate the Students' Use, Experiences and Expectations of the LMSs**

The survey (reported in section 3.2 above), that was carried out to identify the factors that are responsible for the limited success of LMSs in developing country universities highlighted the need to seek ways of using the available ICTs and ICT infrastructure to enhance the students' accessibility of the LMS services. This necessitated that another survey be carried out to explore the current state of the students' use, experiences and expectations of the LMSs with a view to identifying strategies of enabling better access to the LMS services by the students. The findings of the survey are reported in this section and, they were helpful in answering research question (ii) of this study.

The survey was conducted in two universities: Makerere University (implementing the Moodle LMS) and the University of Cape Town (implementing the Sakai LMS). These universities were selected on the basis of two reasons: having carried out a closely-related research study meant that the established contacts in these universities would benefit this study; and, most importantly, however, was the fact that these universities were implementing two of the most popular open source learning management systems—Moodle and Sakai, respectively. And, in addition, the earlier research study had also showed that, while at Makerere University there was relatively little success with Moodle (after attempts with Blackboard and Kewl), the University of Cape Town had a relatively stable and more successful implementation of Sakai. This contrast in success stories would also benefit the investigation.

In this survey, data was collected through an electronic survey or e-survey (electronic questionnaire). An e-survey methodology was used because of the need to reach out to more respondents in a short time without the need to travel. The study was however also aware of the shortcomings that normally affect the effectiveness of e-surveys, which include: respondents' limited access to and familiarity with technology (Thompson *et al.* 2003); how to include incentives for completion, if incentive is to be given (Couper, 2000); response quality (Couper *et al.* 2001); invasion of privacy (Gurau, 2007); and low response rates (Kaplowitz *et al.* 2004). The effects due to such shortcomings of the e-survey method were minimized by the fact that: the survey respondents were university students who were familiar with and had access to technology; no incentives were to be offered to the respondents; the respondents were requested verbally in classrooms before the e-survey link

was sent into their mail boxes; and the intent of the survey was well outlined in the introduction, creating a high perceived importance of the study to the respondents so as to provide genuine responses.

The invitation to participate in the survey including the survey link was sent to students' e-mail lists and, in some cases, directly to individual students' e-mail addresses. The potential respondents were identified with the help of research assistants in the participating universities, who had been contacted earlier. Before sending out the invitation to the students' e-mails, verbal announcements and requests to participate were made in classes so as to avoid the students treating the invitation to participate in the survey as spam e-mail. The survey responses were anonymous, and no incentives were offered to the respondents. However, since the survey required the use of human subjects, there was need to obtain permission in the form of ethical clearance from the relevant university committee (Appendix 3.2).

The electronic survey questionnaire (Appendix 3.3), which was powered by LimeSurvey<sup>21</sup>, an open source survey application, consisted of four sections: Section 1 focused on demographic information of the respondents (students); Section 2 focused on the students' prior experience with learning management systems and comfort level with information technology in general; Section 3 had questions that required the students to rate the different LMS access devices, to score the importance of the various LMS services (on a scale of 1-5) and to select the most needed and most desirable LMS services to them; and Section 4 was the narrative response section, which allowed the students to provide additional comments or suggestions on any issues that were not addressed in the previous three sections of the questionnaire.

The survey targeted about 200 respondents (100 students from each of the two universities). However, a total of 144 valid submissions were obtained, representing a response rate of 72%. The target was 200 respondents and assumed to be sufficient for this study, given that similar studies have targeted and used much smaller sample sizes and have obtained meaningful results. According to studies carried out by Kaplowitz *et al.* (2004), Kwak *et al.* (2002) and Cobanoglu *et al.* (2001), on Web survey study response patterns, profiles, data quality and response rates, the response rate of 72% is acceptable for this kind of study.

The demographic distributions of the students who participated in the survey are shown in Figures 3.1, 3.2, 3.3 and 3.4 below.

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<sup>21</sup> <http://www.limesurvey.org/>

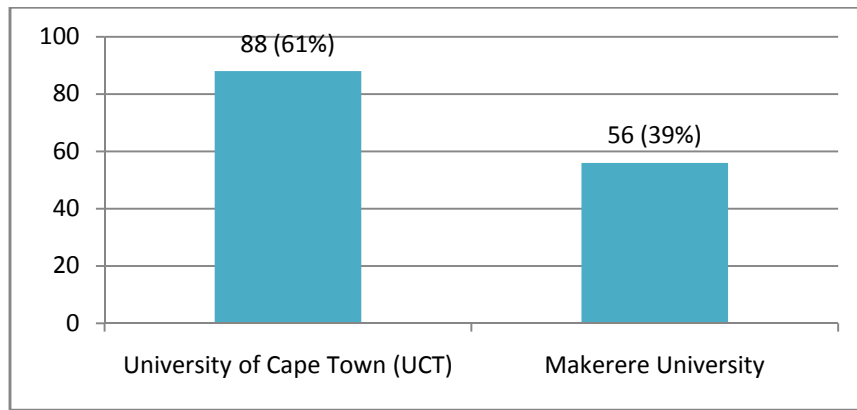


Figure 3.1: Distribution of respondents according to University

As seen in Figure 3.1 above, more responses were obtained from the University of Cape Town (61%) than from Makerere University (39%). This was because the students from Cape Town had more exposure to electronic surveys than the students in Makerere University, and so were more willing to participate. This observation is supported by the claim made by Kwak *et al.* (2002) that, even among the Internet users, some groups tend to be more open to electronic surveys than others. Furthermore, they assert that those demographic groups who are more likely to be early adopters or who use the Internet technology more frequently should be more willing to participate in a survey that is based on the technology. This was also true for the students at the University of Cape Town as opposed to their counterparts of Makerere University.

In fact, to obtain the 56 responses from Makerere University, verbal requests by lecturers had to be made in class, requesting the students to participate in the survey by responding to the request that was sent in their e-mails. Consequently, the response speed of the participants from Makerere University was lower than that of the participants from the University of Cape Town. Actually, all the 88 responses from the University of Cape Town were received within four days of sending out the request for participation and the questionnaire link. For Makerere University, it took more than three weeks to obtain the 56 responses. The difference in the response speed for the participants in the two universities could also be explained by the difference in Internet accessibility and other facilities such as computer labs for the students in the two universities.

Students from specific faculties were purposefully targeted. The targeted faculties were those that were more actively using the LMS, and these were mainly from the disciplines of Science and Technology (e.g. Engineering, Mathematics, Computing and Information Systems). And this was true in both universities. 71% of the participants were from the

faculties of Science and Technology, while 70% were from the faculties of Business and Management, and 2% from Health Sciences (Figure 3.2).

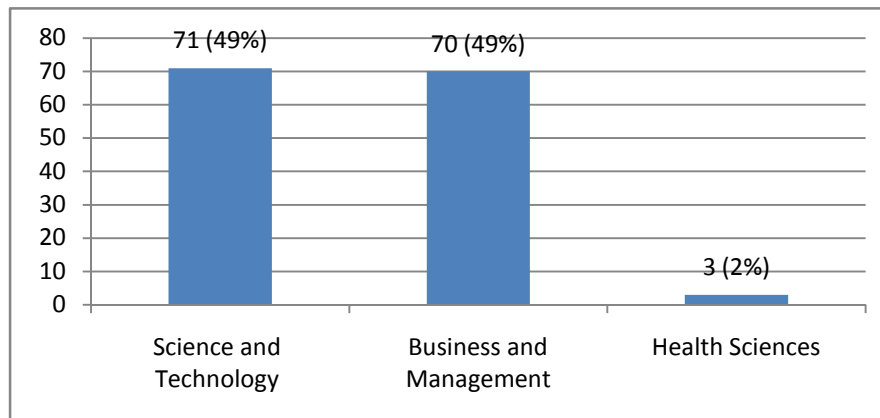


Figure 3.2: Distribution of respondents according to study domain

Information regarding the faculties that were more actively using the LMS was obtained from the LMS server administrators in both universities. Some classes were identified in these faculties and the resource persons were contacted. Through the resource persons, requests for participation and the questionnaire link were sent to the students' mailing lists. There was no formal request sent to the Health Sciences students, therefore the 2% of the respondents indicated as Health Sciences could have been part of the mailing list of a targeted group, or could have been invited by their colleagues to participate.

Undergraduate students were mainly targeted because a background survey showed that these require the LMS for more services than the graduate students. So more requests were sent to the undergraduate classes and consequently the study sample contained more undergraduates than graduate students: 72 % of the respondents were undergraduate students while 28% were graduate students (Figure 3.3). The graduate students also included the Honours students at the University of Cape Town. Honours is a qualification between the Bachelors and the Masters qualifications.

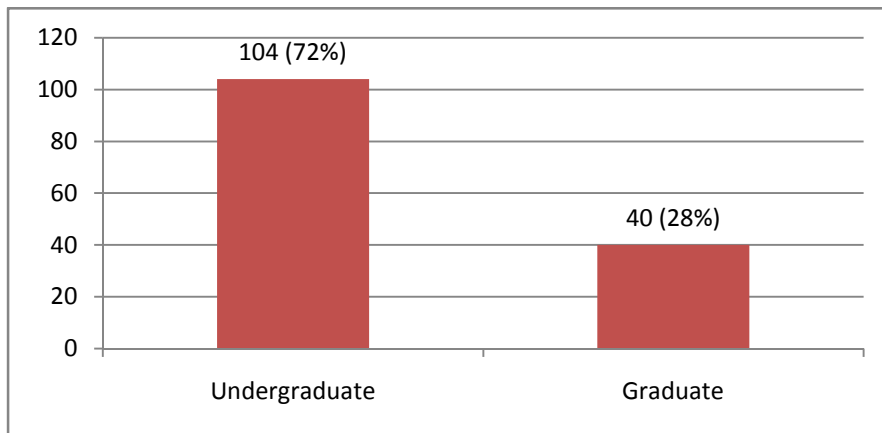


Figure 3.3: Distribution of respondents according to qualification

Furthermore, the students in later years of study (2<sup>nd</sup> year and above), were targeted. This was because these were expected to have had more time to interact with the LMS. 36% of the respondents were in their third year of study (either graduate or undergraduate); 31% were in their second year of study; 20% were in their fourth year of study; while 10% were in first year; and 3% never revealed their year of study (Figure 3.4). With this sample of respondents, the study would be able to obtain more insight into students' experiences with the learning management systems

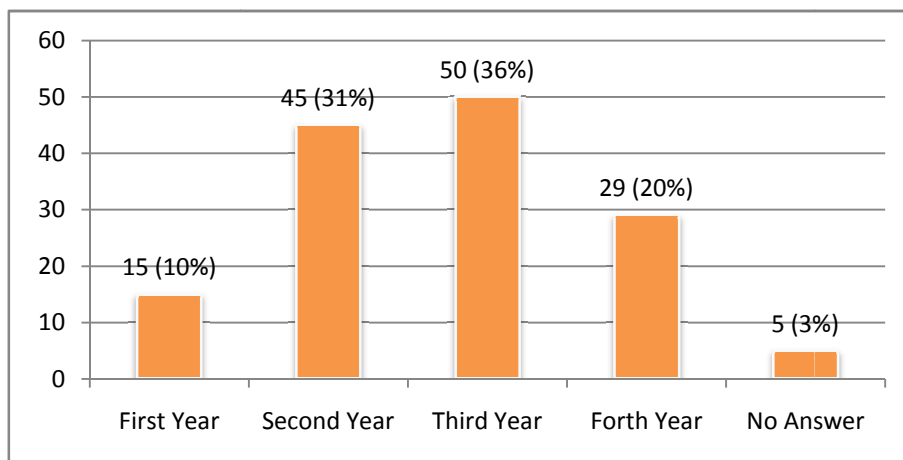


Figure 3.4: Distribution of respondents according to year of study

### 3.3.1 Students' Access to and Ease of use of ICTs

The majority of the students who participated in the survey said that they did not have access to a computer most of the time, whether personal computer/laptop or institutional computer, at the university or at home. This, therefore, limited their access to LMS services both at the university campus and at their residences. Furthermore, the students also reiterated the fact that the rampant power outages at the university meant that even the few available computers

at the university could not be used most of the time due to the electricity outages. This was more pronounced in Makerere University than in the University of Cape Town.

All of the students, however, said that they owned mobile phones. Thus, mobile phone proliferation in the surveyed universities was 100%. Overall, of the mobile phones owned by the students, 77% could access the Internet; out of these, 58% were smartphones while 19% were feature phones (Figure 3.5).

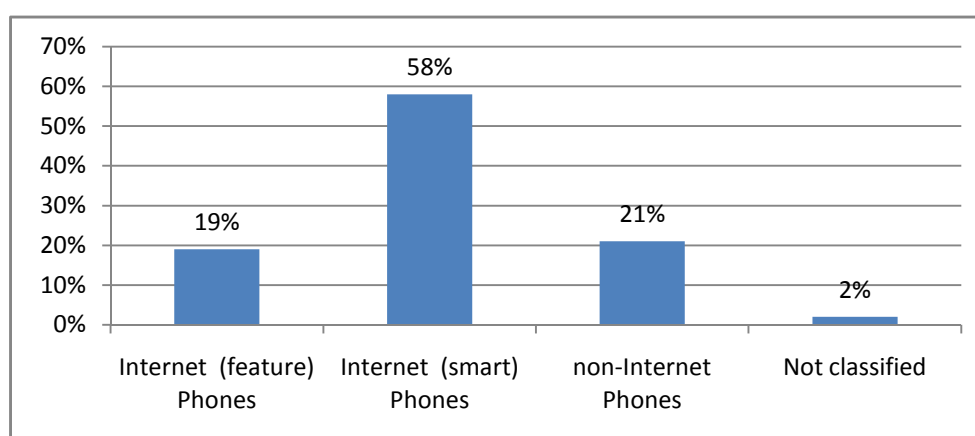


Figure 3.5: Mobile phones owned by the students

The students at the University of Cape Town owned a larger percentage of the smart phones, and the students in Makerere University owned a larger percentage of the feature phones. The 21% non-Internet phones were equally distributed between the two universities. However, as shown in Table 3.1 below, there was a noticeable difference between the students from the two universities in the self-reported comfort levels with technology.

Table 3.1: Differences in students' self-reported comfort levels using technology at the different study universities

	Very Comfortable	Somewhat Comfortable	Neutral	Somewhat Uncomfortable	Very Uncomfortable	Total
Makerere University	13%	18%	7%	0%	1%	39%
University of Cape Town	54%	4%	3%	0%	0%	61%
Total	67%	22%	10%	0%	1%	100%

Overall, 89% of the respondents from both universities reported to be at least 'somewhat comfortable' using technology (Figure 3.6).

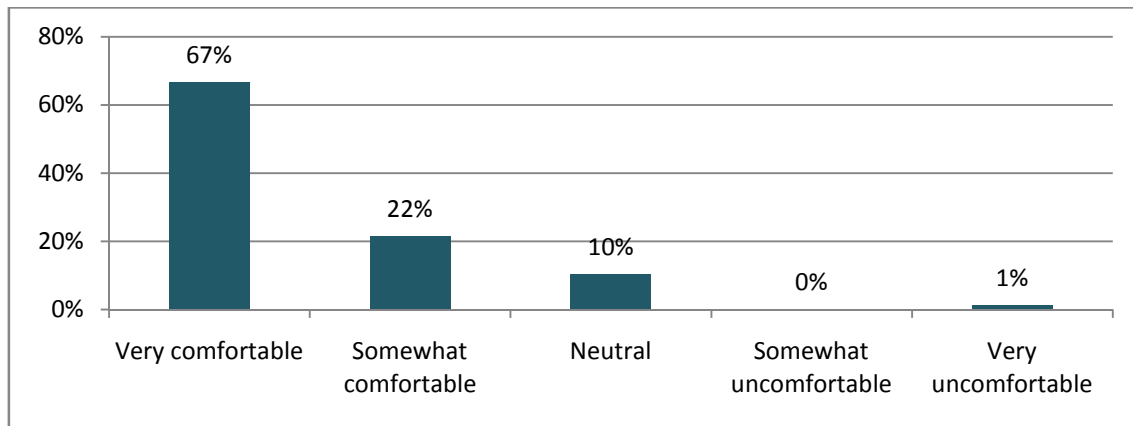


Figure 3.6: Students' comfort level using technology

The students' self-reported comfort levels with technology means that the students have the potential, ability and willingness to use technology solutions once they are available and accessible to them. Additionally, the high proliferation of Internet phones among the students could also be taken advantage of, in enabling them (the students) to access study materials and information off the different repositories, such as the LMSs.

### 3.3.2 Students' Experiences and Access to the LMSs Services

At the University of Cape Town, Sakai (branded 'Vula' locally) is the major LMS used, and all the respondents from UCT had used and were using Vula. At Makerere University, Moodle (branded 'MUELE' locally) is the LMS used, and all of the respondents from Makerere University had used and were using MUELE. The question with respect to experience with LMSs was asked on a five-point scale; (1-Highly experienced; 2-Somewhat experienced; 3-Neutral; 4-Somewhat inexperienced; 5-Struggling). Overall, 80% of the students from both of the universities were at least somewhat experienced in using the LMSs, of which 37% rated themselves as highly experienced in using the systems (Figure 3.7).

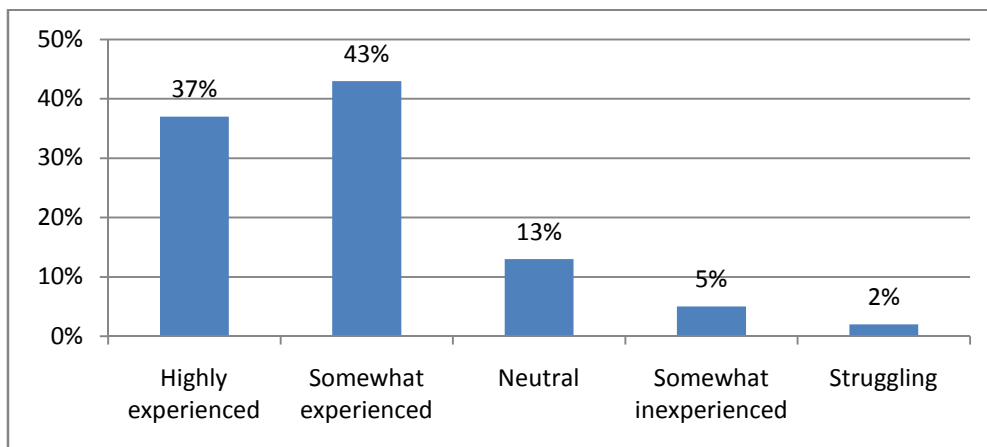




Figure 3.7: Students' experience with LMSs

However, as might have been expected, there was a variation between the students' experiences with LMSs at the different universities. For example, (as shown in Table 3.2) while the majority of students from UCT reported high experience, the majority of their counterparts from Makerere University reported lower experiences, demonstrating the fact that universities and students vary in their use of the LMS technology.

Table 3.2: Students' LMS experiences per university

	Highly Experienced	Somewhat Experienced	Neutral	Somewhat Inexperienced	Struggling
Makerere University	9%	50%	25%	11%	5%
University of Cape Town	56%	38%	6%	0%	0%

Asked how often they access the LMS and the devices they use, 51% of the respondents said that they access the LMS several times a day, while 3% never access the system at all (Figure 3.8).

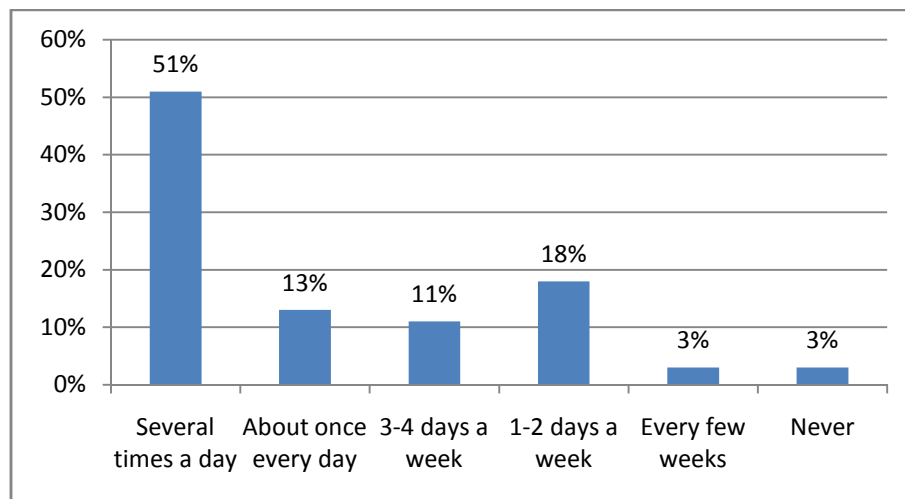


Figure 3.8: Frequency of LMS access by the respondents

On the devices they use to access the LMS, 60% use PCs and Laptops at least most of the time (Figure 3.9), while over 70% rarely or do not use their mobile phones at all (Figure 3.10).

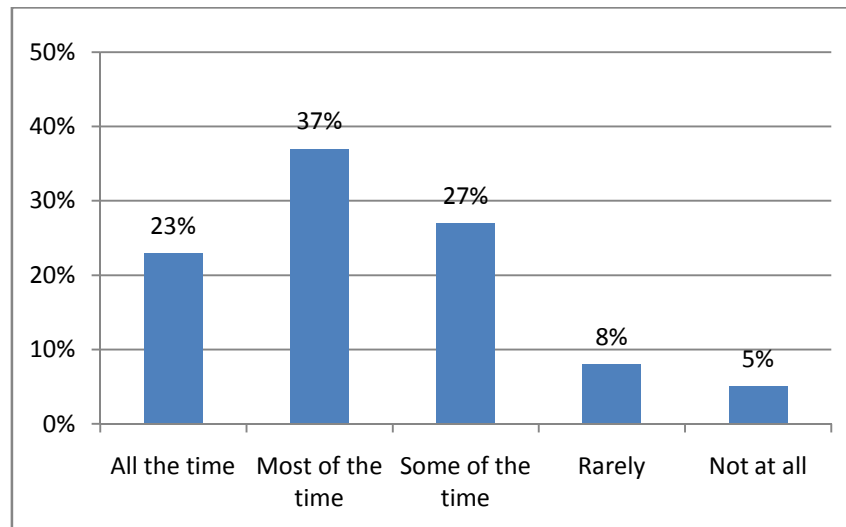


Figure 3.9: How often do you access the LMS using a PC/Laptop?

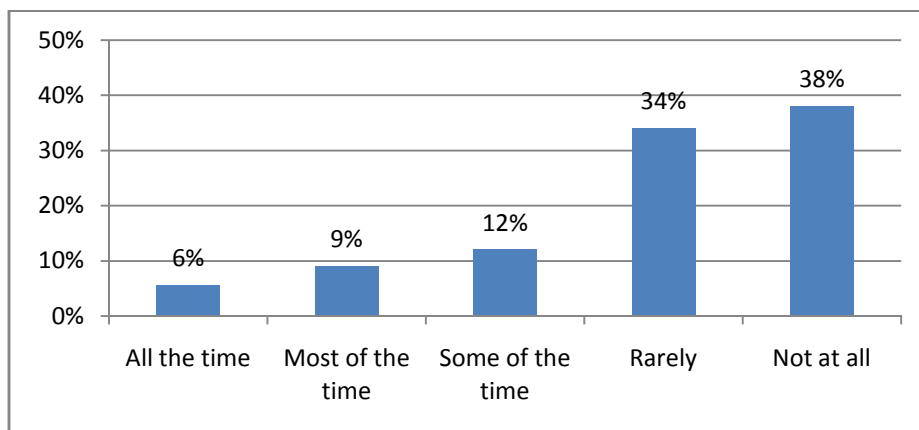


Figure 3.10: How often do you access the LMS using a mobile phone?

Overall there was no variation between the students from the different participating universities regarding the devices they use to access the LMSs. For example, although over 70% of students at the University of Cape Town have smartphones, and almost every smartphone can read and display full desktop websites, the students still do not find it appealing to use phones for accessing LMSs. Instead, the students ranked laptops as the most preferred device for accessing the LMS (Figure 3.11).

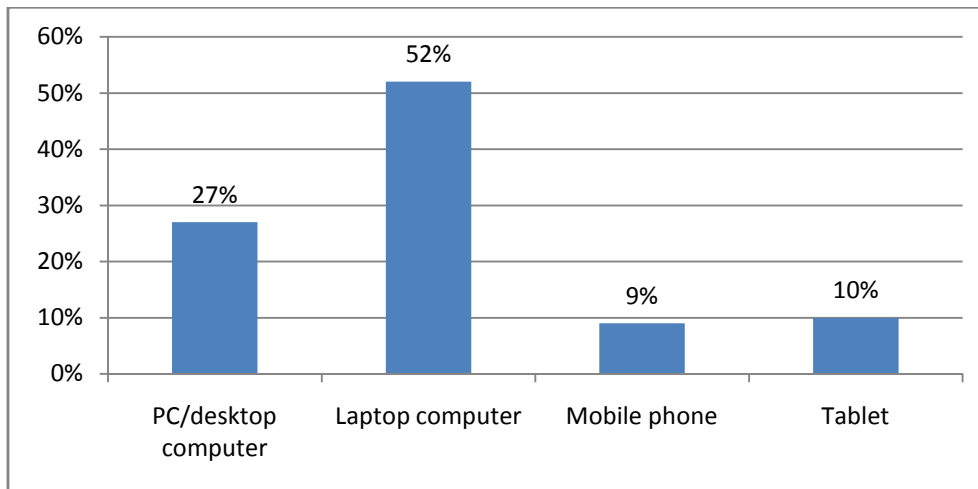


Figure 3.11: Devices used by students for accessing LMSs services

The students' preferences for the different devices used in accessing the LMSs shown in Figure 3.11 above became more meaningful when exploring the qualitative data that contained unique insights and explanations by the students for choosing the devices to use for accessing the LMS services. The explanations, some of which are quoted below, highlight issues of screen size, processing power, portability, power-save, wireless connectivity, power outages, etc.

*"A laptop is the most convenient because it is portable, as fast to open a page as a desktop computer and doesn't need electricity all the time. A mobile phone is more portable but the LMS doesn't open well on the phone, and it is slow when loading the pages. A PC is good but limited to power availability. I don't know about the Tablet."*

*"The laptop takes the first ranking because it is more reliable in terms of electricity and easily portable"*

*"I would have preferred the mobile phone because I have it all the time, but navigation of the LMS on the mobile phone is very difficult, so I am forced to use the desktop"*

*"A tablet is somehow smaller than a laptop or even a desktop, whereas a mobile phone lighter and easy carry compared to desktop and laptop...so I would choose a tablet and mobile phone due to convenience reasons."*

### 3.3.3 Students' LMS Expectations: Most Needed and Most Desired LMS Services

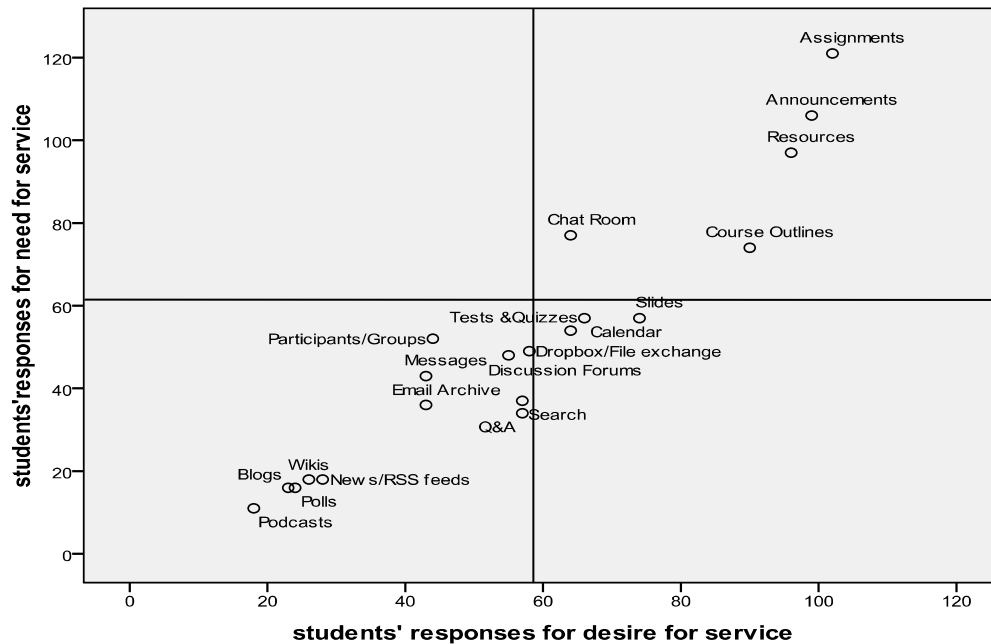
This study defines the most needed services as those that the students are required to access and use most of the time. This need may be as a result of a university policy or standards set

by course facilitators/lecturers. The most desired services are defined as those that the students most want, wish or would like to access most of the time. This may be as a result of a student's individual needs, group needs or the attractiveness of using such a service. The questions with respect to the most needed and the most desired LMS services allowed the students to select services from the list of LMS services were provide. Table 3.3 shows the frequencies (number of times) each LMS service was selected as needed and as desired by the students. The data in Table 3.3 was then used to draw scatter chart with four quadrants (Figure 3.12 showing the different LMSs services in the different quadrants, based on the students' need and desire for the services. The Figure has 'need for the service' on the y-axis and 'desire for the service' on the x-axis.

Table 3.3: Students' ranking for the most needed and most desired LMS services

<b>Service</b>	<b>Number of times the service is selected as needed</b>	<b>Number of times the service is selected as desirable</b>
Assignments	121	102
Announcements	106	99
Resources	97	96
Course Outlines	74	90
Chat Room	77	64
Slides	57	74
Calendar	57	66
Tests & Quizzes	54	64
Dropbox/File exchange	49	58
Discussion Forums	48	55
Participants/Groups	52	44
Search	37	57
Messages	43	43
Q&A	34	57
Email Archive	36	43
News/RSS feeds	18	28
Wikis	18	26
Blogs	16	23
Polls	16	24
Podcasts	11	18

Figure 3.12: A Quadratic scatter chart showing the different LMSs services in the different quadrants, based on the students' need and desire for the services



The four quadrants in Figure 3.12 represent:

- Top Right: The services that are highly needed and highly desired by the students
- Bottom Right: The services that are highly desired but not as much needed by the students
- Bottom Left: The services that are not as much needed and desired by the students
- Top Left: The services that are highly needed but not as much desired by the students

According to Figure 3.12, ‘assignments’ ‘announcements’, ‘chats room’, ‘course outlines’ and ‘resources’ emerged as the most highly needed and desired LMS services. Other services such as slides, tests & quizzes and calendar are also highly desired by the students though not much needed. The rest of the services that include e-mail archive, blogs, wikis, polls and podcasts are not much needed and required by the students. Figure 3.12 also shows that there is no single service that is highly needed but not desired by the students.

In addition to the LMS services presented to the students for selection, the students were also asked to write down any other services that they would like the LMSs to provide. Below is a list of some of the services that the students mentioned.

Grade Book	Free SMS
Assignment Submission	Notification of important deadlines
Video Lectures/Tutorials	Picture blog
Video forums/videoconferencing	Receiving results

### 3.3.4 Summary of the Survey Findings

The findings of this survey have been useful in understanding the students' LMS experiences and expectations in the surveyed universities, and therefore in the answering of research question (ii)

Firstly, the majority of the students from the surveyed universities have been found to have the desire and experience to use learning management systems. They too reported high abilities and self confidence to use the different technology platforms available for accessing the learning management systems. At the same time, although the majority of the students possess smartphones, and would have been expected to use them to access the LMS, they instead reported a stronger preference for using laptops and desktop computers for accessing the LMS. They expressed various views upon which their preferences were based. These broadly included: screen size, processing power, portability, usability, power-save, wireless connectivity and convenience of use.

Secondly, much as the students reported a stronger preference for using laptops and desktop computers to access the LMS services, they did not have access to these devices most of the time, as they do with their mobile phones. Furthermore, the use of such devices, especially the desktop computers require constant electricity supply, and are most of the time dependent on the institutional ICT infrastructure, such as availability of computer labs and local area networks (LANs) and yet, these were found to be a major constraint in the surveyed universities. On the contrary, access through the mobile phones is not entirely dependent on the institutional ICT infrastructure, no need for constant power supply and in addition, in cases of limited institutional internet bandwidth, the students can use mobile phone networks (mobile data) to access the internet and be able to access the LMS services.

The students highlighted that mobile phones present usability and compatibility problems while trying to use them to access the LMS services, and this was indeed the main reason why they (the students) did not use their mobile phones in accessing the LMSs, and instead preferred computers.. In addition to the limitations identified by the students in using the mobile phones to access LMS services, the problem of using mobile phones to access websites meant for desktop or laptop computers has also been highlighted in literature (e.g. Jones, *et al* 2006; Fling 2009).

Thirdly, the study also identified the services that are most desired and needed by the students in the surveyed universities. These included the announcements, assignments, course outlines chat rooms and the resources. This directly answers research question (ii). Therefore, in optimising the LMS by service for mobile access, these services should be given priority.

### **3.4 Identifying the need for Creating more Usable mobile LMS Interfaces**

In addition to answering research question (ii), the findings of the second survey (reported in section 3.3 above), were also useful in identifying the need and informing the design of a mobile LMS application. The study findings indicated that, if the mobile phones are to be more effectively integrated into the LMS ecology, the LMSs have to be optimized for mobile access by designing and developing more usable mobile LMS interfaces. These would encourage the students to use their mobile phones to access the LMS services.

From the reviewed literature, efforts to create mobile LMS interfaces were found to be inadequate. Most of the efforts simply moved desktop layouts to mobile, a practice that has also been condemned in HCI literature. The majority of such efforts have also lacked the full involvement (from design to evaluation) of the end users (students), while some efforts have created platform-specific applications, which also locked out many students. This pointed to the need to create more usable mobile LMS interfaces, and in so doing, putting the students at the centre of the design, development and the evaluation processes. This is what was done in the solution that was developed in this study as reported in the next chapter (Chapter 4).

Designing more usable mobile LMS interfaces would be achieved by either: (i) providing fewer LMS services on the mobile phone, but with all the necessary detail for each service, in this case, these services would be those that are the most needed and desired by the students as identified in the survey reported in section 3.3 above, or (ii) providing all the LMS services with little detail for each service. A third option could also be a balance of the two options; that is, providing fewer services with little detail and defer secondary information to secondary pages, which can be accessible through more optimal devices such as the desktop computers or laptops. The design challenge is to optimize the LMS in such a way that the mobile site (optimized LMS) satisfies at least most of the students' needs and desires for the LMS, and this can be achieved by involving the students in the design and development of the mobile LMS application. If this goal is achieved, the need for desktop and laptop computers for accessing LMS services would be reduced and, the extra cost of accessing the

full LMS would be incurred relatively rarely. This would also reduce the over-reliance and the pressure on the institutional ICT resources for accessing the LMS services all the time by the students.

The design and development of the mobile LMS application is presented in the next chapter (Chapter 4), while the evaluation of the application is presented in Chapter 5.



## CHAPTER 4: THE DESIGN AND DEVELOPMENT OF THE MOBILE LMS (MOBILE VULA)

### 4.1 Introduction

In the two surveys that were carried in this study (reported in Chapter 3 above), it was found out that: Access to LMS services by the students was mainly restricted by ICT infrastructure-related constraints in the surveyed universities; in some cases LMS content remained largely unaccessed and therefore unused by the students; there was need to seek solutions to reduce the impact of such infrastructural constraints by either improving the ICT infrastructure or seeking ways of using the available ICTs and ICT infrastructure to improve the students' access to the LMS services, notably enhancing the access of the LMS services through mobile phones; and that the available LMS interfaces were not suitable for accessing LMSs through mobile phones. For example the mobile Sakai interface that existed at the University of Cape Town did not give a satisfactory user experience to the students as the application was congested and the layout was similar to the desktop layouts. The findings of the surveys thus demonstrated the need to design and develop more usable mobile LMS interfaces for more effective optimisation of the LMS for mobile access. Achieving this would provide an answer to research question (iii) of this study, which is: *“How can we partition the services of an LMS for accessibility through mobile computing devices such as mobile phones?”*

It was further identified through literature that the design and development of more usable mobile interfaces needs to have the users at the centre of the design and the development process. In most of the reviewed efforts towards designing and developing mobile LMS interfaces, however, the requirement of user (student) involvement was either minimally or not at all complied with. In this study, mobile LMS interfaces (mLMS) for accessing selected LMS services on mobile phones were designed, developed, implemented and evaluated. This chapter presents the mLMS user interface design which involved students in a participatory design process and the development of the mLMS application. Much of the work presented in this chapter has been published in a journal article titled *“Designing mobile LMS interfaces: learners' expectations and experiences”* (Ssekakubo *et al.* 2013). The evaluation for ease-of-use and usefulness, and impact assessment of the developed mLMS application is presented in the next chapter (Chapter 5).

## **4.2 Optimisation of Full Desktop Sites for Mobile Access**

Literature on optimization of websites for mobile phone access (e.g. Nielson 2012) reveals that websites can be optimized for mobile access in two ways, either:

- (i) Enable access to fewer services through the mobile phone, but with all the necessary detail for each service; or
- (ii) Enable access to all the website services through the mobile phone, but with little detail for each service.

As presented in the literature review (Table 2.4), LMSs have several service components. A typical LMS like Sakai or Moodle will have over 20 services. Some of the LMS services are occasionally (or not at all) used/accessed by the students. The most feasible and appropriate way to optimize the LMS for mobile access would therefore be to provide access to a few selected services on the mobile phone. Each service would be provided with the necessary detail and, where necessary, secondary information would be deferred to secondary pages, which can be accessible through more optimal devices such as the desktop computers or laptops. As Nielson (2012) argues, if this is achieved, the extra cost of accessing the full site would be incurred fairly rarely.

## **4.3 Design of the mLMS Interfaces**

Through a survey that was conducted to investigate the students' expectations and experiences with LMSs (Chapter 3), the students identified the most important (most needed and desired) LMS services. The most highly needed and desired LMSs services by the students, as shown in Figure 3.12, were therefore the ones to be provided for access on the mobile phone in the first prototype. These included: assignments, announcements, resources, course outlines and chat rooms.

Having identified the LMS services to provide access for on the mobile phone, the next task was how to design the mobile interfaces and develop the application through which such services could be satisfactorily accessed by the students through their mobile phones. The task was approached and achieved through a user-centred design (UCD) approach, specifically participatory design.

According to Winograd (1996), user-centred design is an approach to software design that grounds the process in information about the users of the software product. The UCD approach, as also argued by Petrelli *et al.* (2005), involves the users at the early stages which

compels the designers and developers to think towards application utility and usability and helps to focus on what is actually needed. The process of the mLMS design and development focused on students through the analysis, design, implementation and evaluation of the application. The main aim was to design and develop an application that is usable and meets the requirements of the students in their context of use. Typically, as shown in Figure 4.1, the UCD approach incorporates three principles:

- Involve users and give them high priority;
- Use rapid prototyping in the design phase to produce a number of prototypes that can be revised through user feedback (Farrell and Carr, 2007); and,
- Be incremental throughout the whole process, because a number of revisions are necessary to improve the quality of the application through a continuous cycle of gradual refinement (Hadjerrouit, 2010).

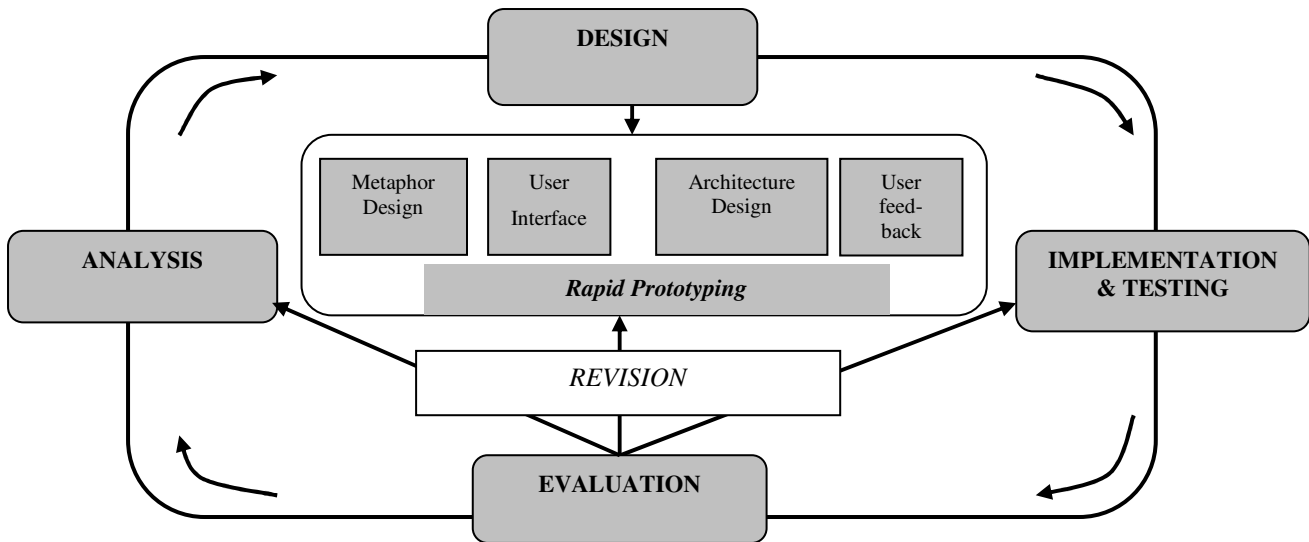


Figure 4.1: Learning application development as a continuous cycle of gradual refinement with four stages.

*(Re-drawn from Hadjerrouit, 2010)*

Further to the understanding and appreciation of the user-centred design approach, Murphy (2004) and Penna *et al.* (2007) reiterate that a UCD-based design procedure should follow the following steps:

- Define the target audience to produce a general description of the users. This information is used to identify a useful design;
- Conduct a user task analysis to understand the users' goal and their mental models;

- Generate a prototype to define how the system works from the user interface perspective;
- Test the prototype with real users using the evaluation methods available;
- Create a better version of the system and give it out to a restricted number of users for evaluation (unlike the prototype, this version incorporates all the functionality available in the final system); and
- The user-centred design process continues to evaluate the system after it is launched, improving it from the users' perspective.

Specifically, as highlighted in Figure 1.2, in Chapter One, the design of the mLMS interfaces was achieved through a participatory design process (Jones and Marsden, 2006). The process involved students at the University of Cape Town (UCT). At the University of Cape Town, the Sakai LMS is used, thus the design of the mobile LMS interfaces for accessing selected LMS services was implemented with Sakai LMS. At UCT, Sakai is locally branded as “Vula”, and so the mLMS interfaces were dubbed mobile Vula (mVula).

In designing mVula, all the steps above were followed. That is:

- The target audience was defined; these were the students using Sakai (Vula) at the University of Cape Town. Information (description) on the students' access and use of Vula was obtained through a survey, and this information was useful when deciding the nature of the intervention.
- A user task analysis was conducted to understand the students' goal for using Vula, their expectations and their mental models for accessing Vula on mobile devices;
- A low fidelity prototype to define how mVula works from the user interface perspective was generated, and it was validated with real users;
- A working prototype was tested with real users using the evaluation methods available. This version of the prototype incorporated most of the functionality available in the final system; and
- A better version of the system was created and also evaluated with real users. This prototype incorporated all the functionality available in the final system.

#### **4.3.1 Designing Mobile Vula (mVula)**

As highlighted above, the design of mVula interfaces was achieved through a participatory design process with students at the University of Cape Town. According to Sanders *et al.* (2010), participatory design sessions can be conducted with either individuals or with people

in groups, the groups can vary in size from two people to large numbers of people. However, Sanders *et al.* (2010) also noted that working with individuals or small groups makes it easier to probe, understand and capture unique individual experiences.

In this study, a total of 13 students were recruited to participate in the design process of mobile Vula interfaces. The participants were randomly but purposefully recruited (e.g. first year students were not used because they were assumed not to have had enough experience using the LMS). The participants were mainly from the second and third year classes, and were picked directly from classes. Upon accepting to participate in the exercise, meetings with them were organised in groups of 2s and 3s. Meetings such as these, that are planned and designed to obtain perceptions on a defined area of interest in a permissive environment, are referred to as focus groups (Krueger, 1994). Sanders *et al.* (2010) define permissive environment/venue for the focus group discussions as the participants' own environments (home, work, school, etc.), in the design studio or the research lab or in a generic facility/conference room.

Focus groups are one of the methods of user-centred design that are used in requirements gathering. They are most often used as an input to design. In the focus group discussions that were conducted for this design process, the meetings were held in a boardroom and the students were probed for their opinions, attitudes and ideas on optimising an LMS for mobile access. The idea of creating mobile interfaces for Vula was discussed with them. While some students had actually tried accessing the full desktop Vula site on the mobile phones before and others had accessed Vula on their mobile phones through another intermediary application, the idea of optimising Vula by providing access for a few selected Vula services on the mobile phones appeared completely novel to the majority of the students. During the focus group discussions (or semi-structured interviews) with the students (which lasted 10-15 minutes) some interesting ideas about their expectations for mobile Vula came up, and these were noted. For example some students suggested that the mobile Vula interfaces and the application be service-based while others suggested that the interfaces should be course-based. Service-based is where the LMS content is organised and presented according to services (such as announcements, assignments) on login, while course-based is where the content is organised and presented according to the courses on login.

The students were then engaged in participatory co-design sessions. According to Jones and Marsden (2006), participatory design actively involves the participants (selected from the user community) in the design and decision-making processes, leading to context appropriate solutions that are likely to be adopted by the users.

The participants were provided with pencil and paper and were asked to draw storyboard sketches of what they wanted the mVula interfaces for the selected services to look like (Figure 4.2)

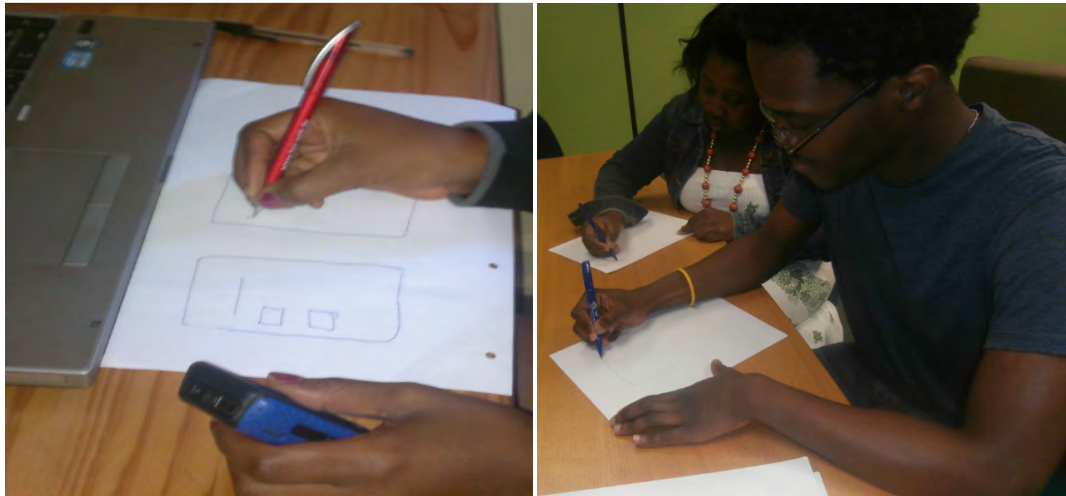


Figure 4.2: Students participating in the co-design session of mVula interfaces

At first, this did not work out well, as most students did not know how to represent mobile phone interfaces on paper, and those who had an idea also wasted a lot of time drawing pictures of full mobile phones (screen, buttons, keypads etc.) other than sketching the interfaces. Figure 6.3 below shows some of the sketches obtained from the first group of students in the co-design session.

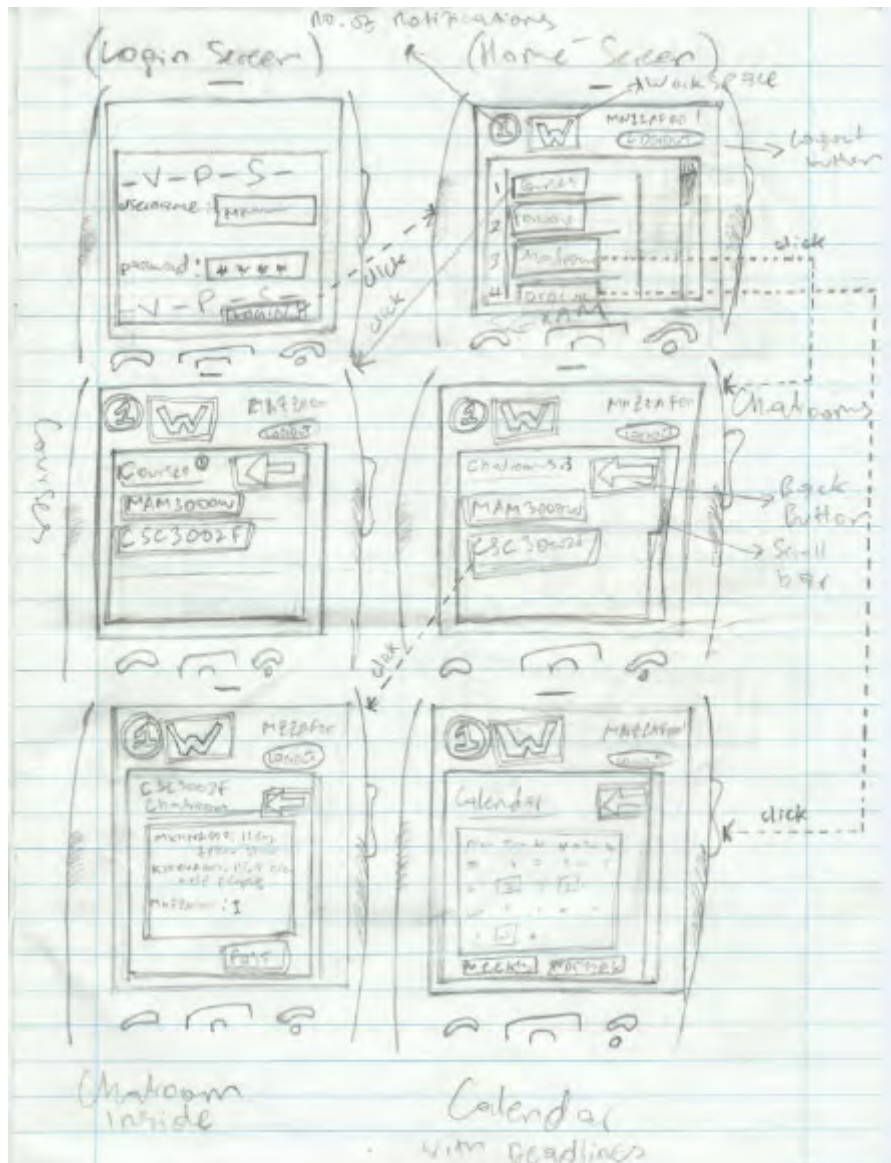


Figure 4.3: Some storyboard sketches for mVula obtained from the first group of students in the co-design sessions.

For the subsequent groups, the co-design sessions were improved by providing familiar mobile phone screen templates (Figure 4.4) instead of the plain paper, such that the students could now draw the interfaces within the templates. This improved the process greatly, and more informative storyboard sketches (Figure 4.5) were obtained from the students within a short time.

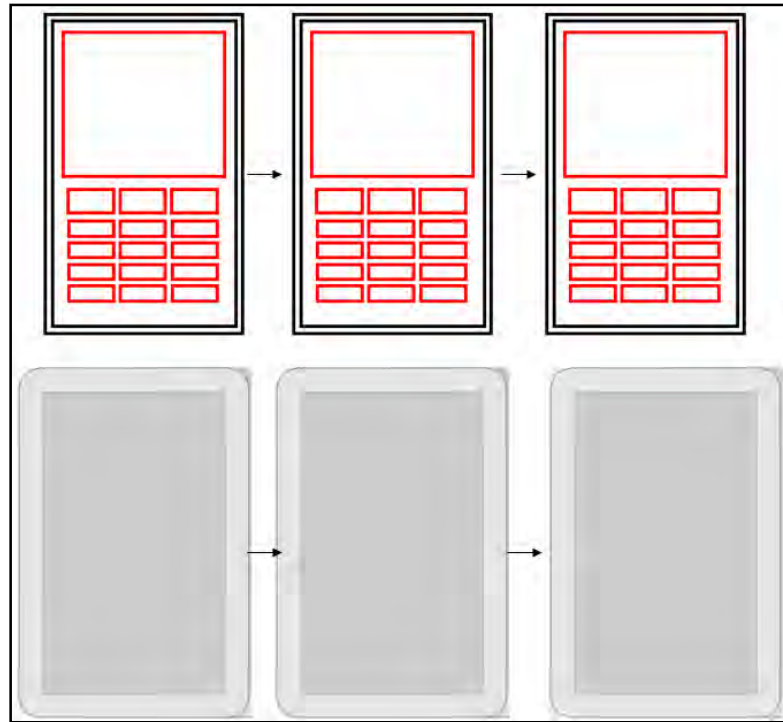


Figure 4.4: Templates for mobile phone screens

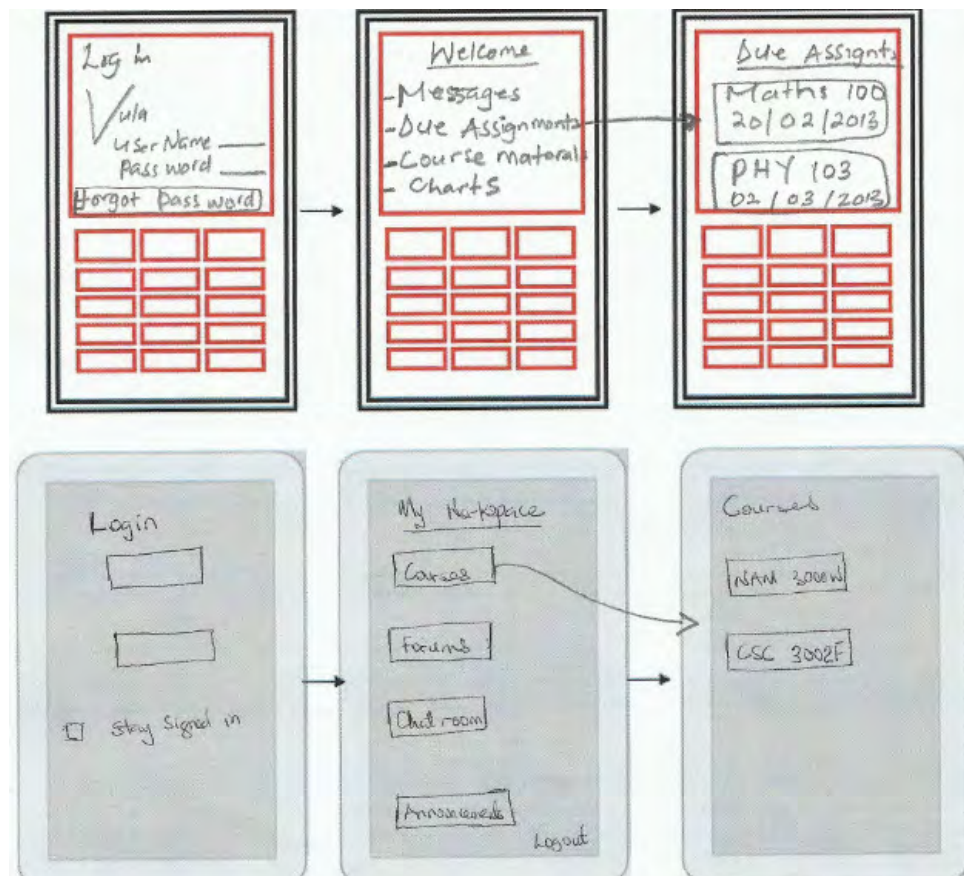


Figure 4.5: Some storyboard sketches for mVula obtained from the subsequent focus groups in the co-design sessions



From the storyboard sketches drawn by the students, the first paper prototype interfaces were created, representing two opposing ideas from the students' sketches: course-based and service-based interfaces (Figures 4.6 and 4.7 respectively). These were again validated with the students.

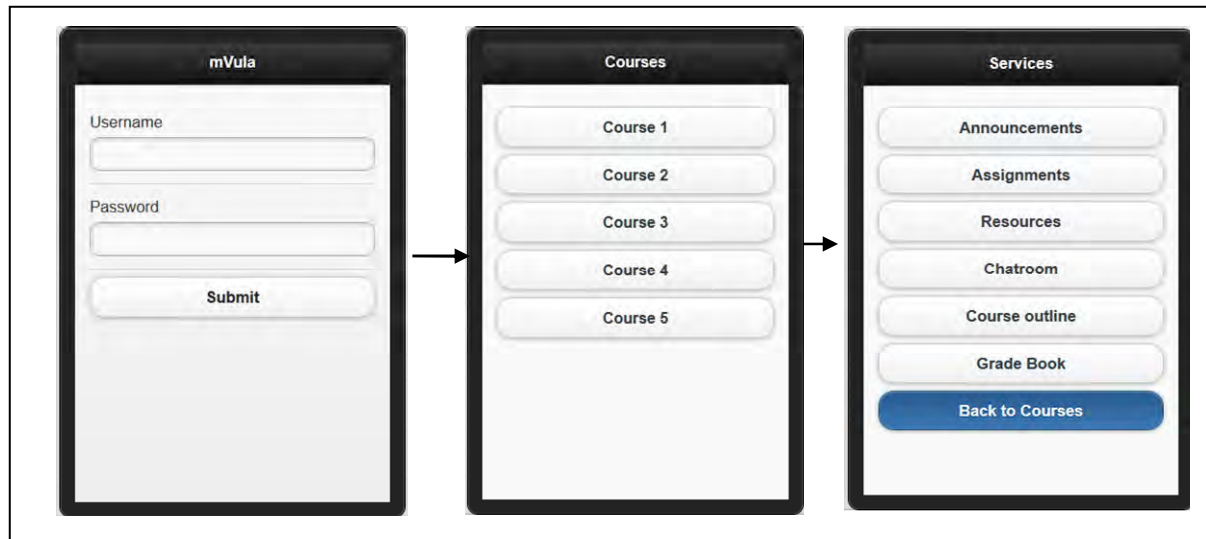


Figure 4.6: Paper prototype 1a: Course-based

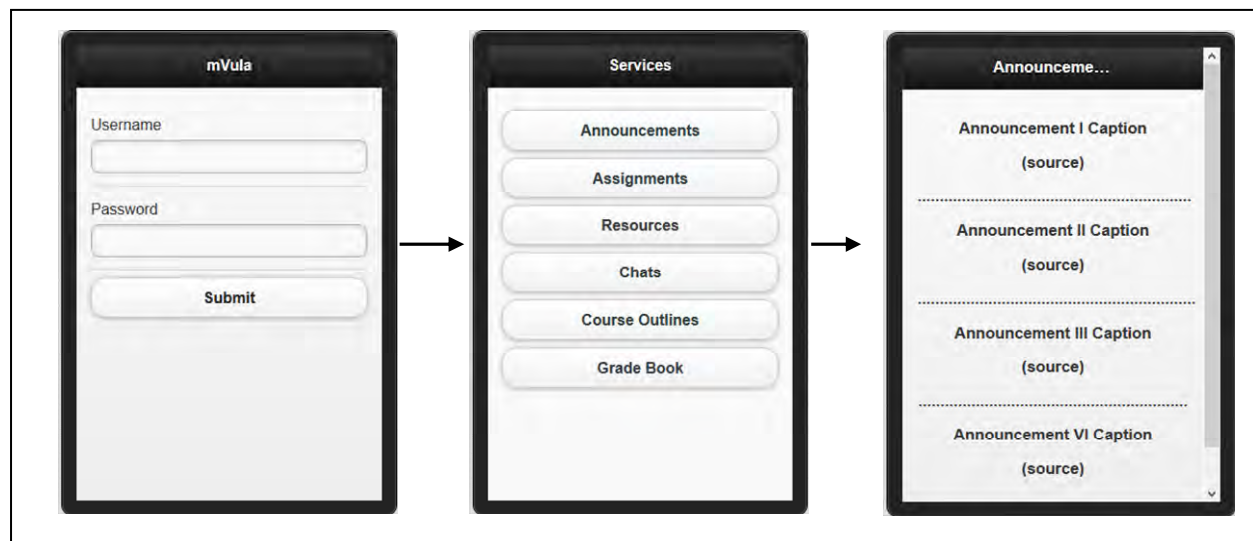


Figure 4.7: Paper prototype 1b: Service-based

Both of the prototypes (Figures 4.6 and 4.7) were given to students to be validated and to choose the more appropriate and seemingly more effective arrangement and flow of information. When invited for this validation exercise, 10 students out of the 13 turned up.

Eight (8) out of the 10 students selected the service-based prototype and, in addition, they suggested that the services be block-based instead of tab-based.

The key design issues learned from the participatory design process included:

- Having straight-forward non-congested mVula interfaces;
- The application to focus on presenting services (as opposed to being course-based);
- The services be block-based;
- Having fewer clicks through the application before the required information is obtained by the user; and
- Services like announcements to be populated with information from across the various courses, and presented according to date.

Figure 4.8 below presents the final paper prototype of the mVula interfaces that was generated.

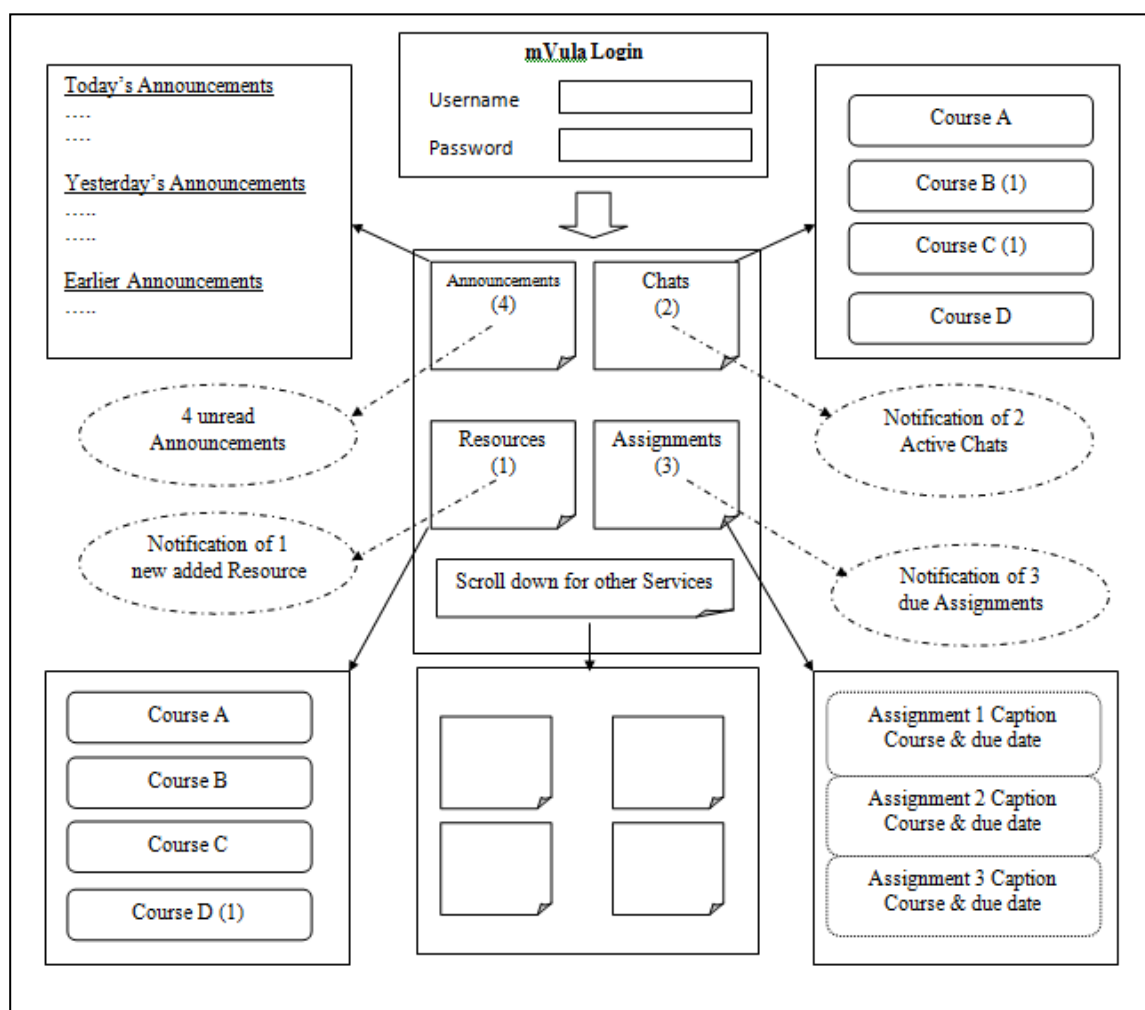


Figure 4.8: Final paper prototype of mVula interfaces

## **4.4 Development of mVula**

After generating the final paper prototype of mVula through the participatory design process, the next step was then to develop a working prototype of mVula.

As already highlighted in literature, there were two ways to develop the mVula application: either (i) to develop mVula for a single mobile platform (native application) and test the ideas on that one platform or (ii) develop a cross platform application and test the ideas across all the major platforms.

While the native application option would be easier and straight-forward in terms of development, such an application would be restricted to a single platform and only students with mobile phones with that particular platform would be able to use the application. Yet, the study would benefit more from feedback (about the ideas presented in mVula) from as many students as possible using a wide range of mobile phones, possibly with different platforms. Yet again, developing separate native applications for the different platforms would require a lot of time, and it would also be difficult to implement and maintain the several native applications. It was therefore more appropriate and feasible to develop mVula as a cross-platform application so as to capture as many users as possible across the major platforms. However, this also presented a different set of challenges, such as the limited number of technologies available to develop cross-platform applications, and the fact that such an application would not be able to utilise some smartphone features (such as the notification feature, the calendar feature) that could possibly be required.

### **4.4.1 Technologies for the Development of Cross-platform Mobile Applications**

In the recent past, the smartphone industry has experienced a major development that has seen most of the current generation of smartphones built with a compatible underlying browser engine, called WebKit (Fling, 2009). WebKit is an open source library that renders HTML. It eliminates the incompatibilities among mobile browsers, making it easier to develop cross-platform Web applications. This means that any WebApp developed for WebKit would easily be rendered by the browsers of most smartphones.

Additionally, there are cross-platform mobile development tools (XMTs) (examples in Table 4.1) that can be used to create apps for different smartphone platforms from the same code base (Hartmann *et al.* 2011; Tsai *et al.* 2007). This development does not only reduce the

coding load, but also ensures that the services provided through such an application would reach a wider audience of potential users (Ribeiro and da Silva, 2012).

However, although mobile Web applications do not make any explicit assumptions about features of the delivery context, best practices assume devices with support for standard XHTML, JavaScript and CSS capability (W3C n.d). Thus, cross-platform mobile applications are typically Web applications. The World Wide Web Consortium has defined Web application as a term that refers to a Web page (XHTML or a variant thereof + CSS) or collection of Web pages delivered over HTTP that use server-side or client-side processing (e.g. JavaScript) to provide an "application-like" experience within a Web browser.

Table 4.1: Some of the Cross-platform mobile applications development Tools(XMT)

XMT	Android	Bada	Blackberry	iOS	MeeGo	Symbian	webOS	WP7	MinMob
Application Craft	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flash Builder	✓			✓		✓		✓	✓
Illumination Software Creator	✓			✓					
jQuery	✓	✓	✓	✓	✓	✓	✓	✓	✓
LiveCode	✓			✓		✓			
Marmalade	✓	✓	✓	✓	✓	✓	✓		
MonoCross	✓	✓	✓	✓	✓	✓	✓		✓
MoSync	✓		✓	✓		✓			✓
OpenPlug Studio	✓		✓	✓		✓			✓
PhoneGap	✓	✓	✓	✓		✓	✓	✓	✓
Rhodes	✓		✓	✓		✓		✓	✓
RhoStudio	✓		✓	✓		✓		✓	✓
Titanium	✓			✓					✓
XUI	✓	✓	✓	✓	✓	✓	✓	✓	✓
Zepto	✓	✓	✓	✓	✓	✓	✓		✓

*Source: Ohrt et al. (2012), plus the individual websites of the presented tools*

Table 4.1 above shows some of the cross-platform mobile application development tools, and the mobile platforms each supports, as of April 2013; the situation is dynamic, and could change (or have changed). Although the table does not show an exhaustive list of cross-platform mobile application development tools, all the tools presented support Android and iOS, while BlackBerry, Symbian and WinMob are also well supported. In this case, the tools

that support most or all of the major mobile platforms were considered for selection for the development of mVula. However, as already noted, HTML and JavaScript are a prerequisite for cross-platform Web applications. Therefore, choice of the final XMT for the development of mVula also depended on the tool's supporting programming languages (Table 4.2).

Table 4.2: Supporting programming languages for some XMTs

XMT	Programming Language
Application Craft	JavaScript, HTML, CSS, Visual Editor
Flash Builder	Action Script and MXML
Illumination Software Creator	None (drag-and-drop)
jQuery	JavaScript, HTML, CSS
LiveCode	Livecode
Marmalade	C++
MonoCross	C#
MoSync	C++
OpenPlug Studio	Action Script and MXML
PhoneGap	HTML and JavaScript
Rhodes	JavaScript, HTML, CSS, Ruby
RhoStudio	Ruby
Titanium	JavaScript
XUI	JavaScript, HTML, CSS
Zepto	JavaScript, HTML, CSS, Visual Editor

Source: Ohrt et al. (2012) and <http://www.markus-falk.com/mobile-frameworks-comparison-chart/>

From Tables 4.1 and 4.2, it is apparent that Application Craft and jQuery were the most appropriate tools for the development of mVula as a cross-platform mobile application. However, as Ohrt and Turau (2012) argue, the option of using a familiar tool can also be a strong incentive in selecting a certain XMT over the other(s). In that regard, jQuery was selected over Application Craft for the development of mVula.

#### 4.5 mLMS Architectural Framework and the Description of the mVula System Setup

The mLMS system needed to be set up in such a way that the mLMS application is hosted on an intermediary server (the mLMS server) and that the mLMS could be accessed as a Web application on the mobile phone (Figure 4.9). Although it would have been technically possible for the mLMS application to reside on the LMS server, this was avoided.

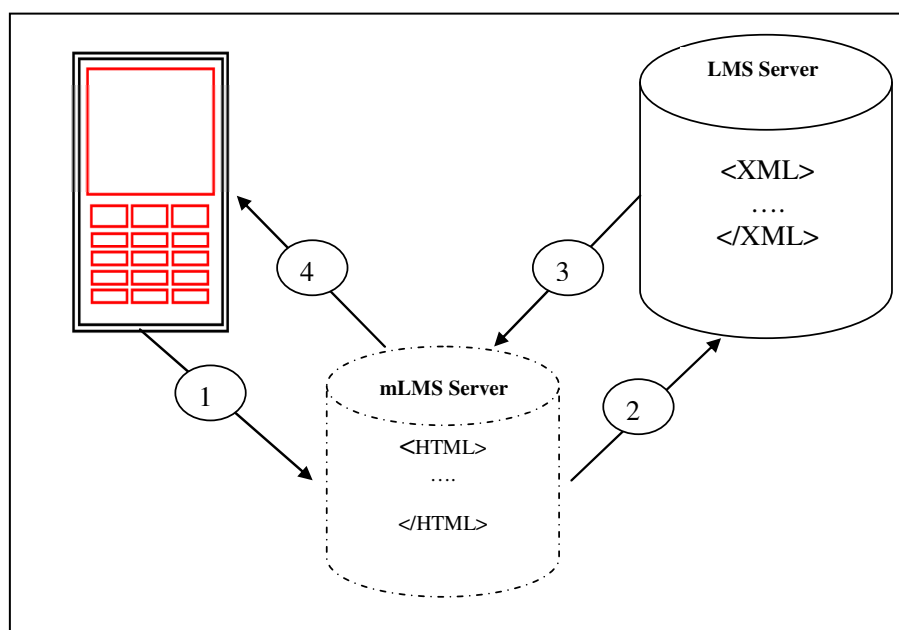


Figure 4.9: mLMS architectural framework

The architectural framework shown in Figure 4.9 ensured that the risk of ‘messing up’ or crashing the University LMS server would be minimised, given that there was no direct access to the system data (which would probably never be allowed for an academic project). The separate installation (intermediary server) also allowed more flexibility with what with the mLMS application setup, and ways in which the data could be presented to the users. The arrows (1-4) in Figure 4.9 indicate that the LMS information requested for by the mobile user is fetched from the LMS server through the mLMS application server.

One problem experienced with the setup was that some REST interface implementations of Vula were incomplete, making it difficult to access some of the user data. To access some information and aggregate it in categories, required making numerous HTTP calls to the Vula site. Without such calls, the presentation of mVula interfaces would not have been different from the current Vula desktop interfaces. For example, under the announcement service, all the announcements that the user has from different places in the LMS are displayed. In order to build this result for the user, there is a need to go to each course that the user has, then go to each announcement and then pull all the announcement information and present it to the user under the announcement service.

Had it been possible to work on the Vula server directly, it would have been easier to supply the user with results to their queries much faster and probably more efficiently. Figure 4.10 below shows the actual mVula and system setup with respect to the need for an intervention

in accessing LMS content on the mobile phone as was presented in the LMS accessibility setup in Figure 1.2.

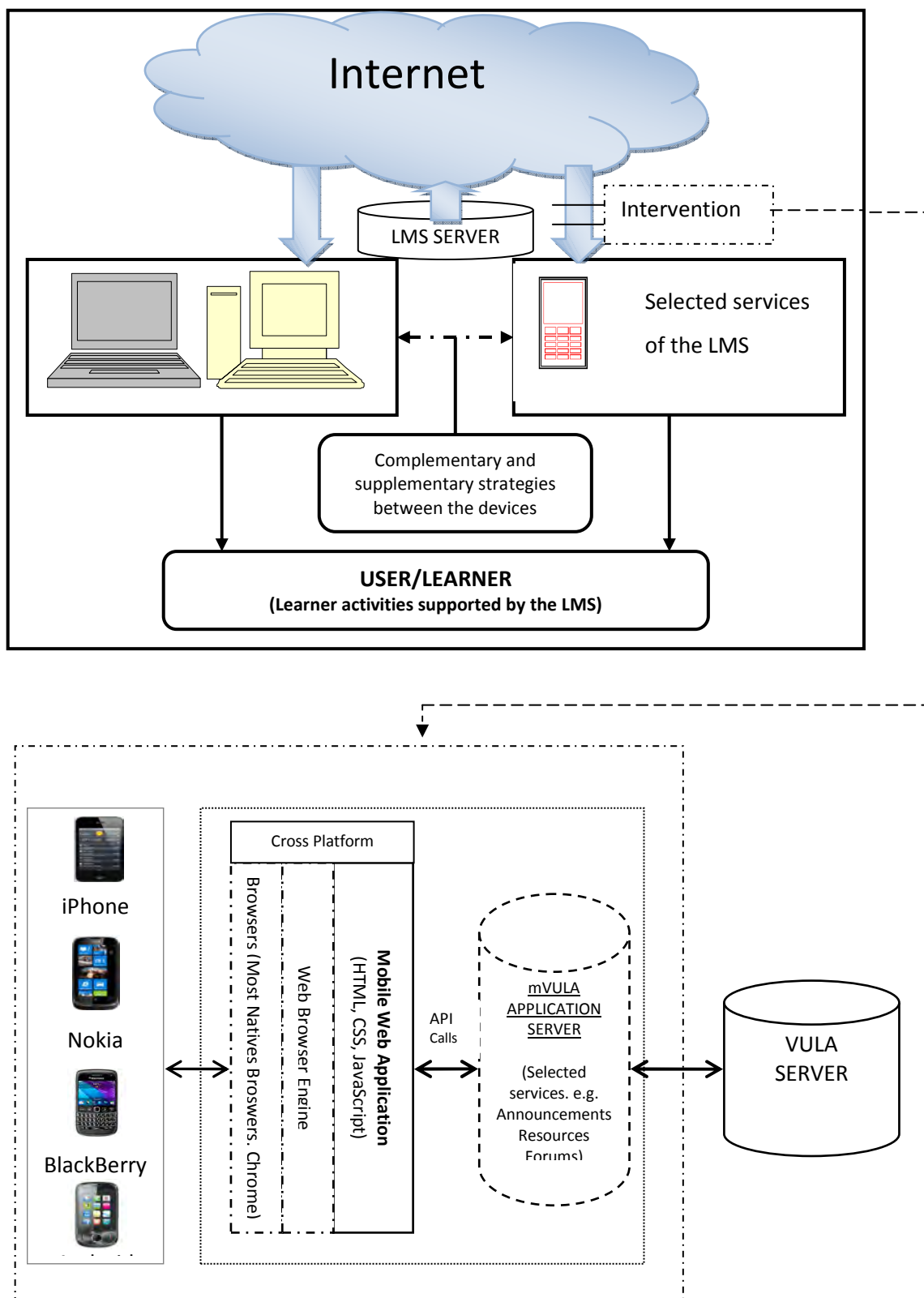


Figure 4.10: mVula system setup

#### 4.5.1 The Client Side and the Back end of mVula

The client side of the mVula application was developed using JavaScript, HTML and CSS while the back end of the application was developed using PHP, linking to the LMS server via SOAP and REST endpoints, and in cases where the REST points were inactive or not available (which was the case for most services), HTML was scraped from the existing Vula portal.

Originally, the development of mVula was planned to be based on APIs. However, it was realised that the usage of the Vula APIs at the University had not been given much attention (had been almost completely abandoned) by the Vula administrators for various reasons. The version of the Vula API that was being run at the university did not have most of the REST points implemented. Only the announcements could be accessed through the API successfully. However, on accessing the announcements information via the API, some information (such as the course/group that the announcement was from) was not made available. Moreover, this information was needed in order to organise the announcements for the users. With such information missing, the announcements could only be organised by date, with the hope that the users would receive enough context from the announcement that they would know where it was from. However, on evaluating the first prototype of the application, the users required that, in addition to the announcement's title and date, its source should also be included in the caption. Consequently, scraping the Vula portal was the most feasible option to get the required information. This worked well and was replicated for the rest of the services.

CURL and PHP were used to log into the Vula portal using the usual HTML site that the users would be exposed to. On successfully logging in, the login cookie would then be stored, and used to get a list of all the user's courses/groups that the user would be registered for (assigned to) on the worksite setup page. This was done by using the "*htmlDOMpparser*" PHP script.

This exposed the XHTML document, making it possible to look for specific elements and extract the content within. In order to get the correct elements, it was needed to browse each page that information had to be extracted from and locate the names and types of the required elements. In other cases there was need to use additional tools such as "*greasemonkey*", but usually Firefox with the developer console exposed gave enough information about redirects, etc. Once all the user's groups are known, the information is stored in a user session so that it



is persistent over user calls such that there is no need to have to make the calls again. The user is then presented with options of viewing the selected services (announcements, assignments, resources, chats, etc). The user is never redirected to any pages during the navigation of the site. The entire front end is a single HTML page with a jQuery mobile theme. All queries to the server are done via AJAX calls.

#### **4.5.2 Functionality and Screenshots of the Interfaces of the mVula Application**

The mVula application can be accessed through a Web address (<http://simba.cs.uct.ac.za/mVula>). Once the Web address is entered in the mobile phone browser, the application index page, which is the mVula login screen, appears, requiring a username and password. These are the same as the user credentials for the University students/staff, and are verified by the Vula server. Once the login is authorized, the browser returns a screen containing blocks of the Vula services optimized for mVula (Figure 6.11). Once a service block is “touched” or “clicked”, it opens to display the information, say, the captions of the announcements with the latest announcement on top. Touching or clicking the announcement caption opens and displays the announcement.

Using the mVula application, the user goes through two or three steps (touches/clicks) to obtain the required information (Figure 4.11). Navigation through the application interface can be achieved with the system buttons of the mobile phones in addition to the “bread crumbs” provided on each application interface.



Figure 4.11: Screenshots of the interfaces of the working prototype of mVula

## 4.6 Summary

Overall, the design and development of mVula was user-centred. Specifically, the mVula interfaces were designed through a participatory design process with the students.

During the design process, it was noted that some of the students who participated in this study (and possibly the majority of students in developing country universities) exhibited behaviours that had not been previously reported in the literature in the use (and ability) of their smart mobile phones. This may be symptomatic of technology “leap frogging,” where the new Internet users among the students are obtaining access by mobile devices and are skipping the traditional means of access. This has to be taken into consideration when

involving such users in the design process of mobile interfaces. For instance, in our case, some students did not know what to expect in streamlined mobile interfaces for an LMS, and how different such interfaces could be from the full LMS interfaces meant for computer access. The fact that we had to prepare and use mobile screens templates instead of plain paper during the co-design sessions with the students to generate paper prototypes may also indicate a lack of clarity in the difference in the roles between mutable software and immutable hardware.

Based on ideas presented by the students in the co-design sessions, paper prototypes of the interfaces were generated and validated by the students to produce a final low-fidelity paper prototype. The low-fidelity paper prototype was then developed into a functional prototype of mVula.

Mobile Vula was developed as a cross platform mobile Web application. JavaScript, HTML and CSS were used to develop the client side, and PHP was used for the back end.

Two prototypes of mVula were developed, implemented and evaluated in an incremental process. The next chapter (Chapter 5) presents the evaluation process of mVula as well as the results of the usability evaluation of the mVula application and the overall impact assessment of the mVula intervention.

## CHAPTER 5: EVALUATION

### 5.1 Introduction

This chapter reports the evaluation of the mVula application that was designed, developed and presented in Chapter 4. The application was intended to: enhance LMS accessibility on mobile phones; and encourage the students to use their mobile phones to access the LMS services. The purpose of the evaluation was therefore to assess whether the mVula application is usable and useful to the students and, leads to increased use of the LMS (Vula) by the students through their mobile phones.

Firstly, the evaluation process was useful in the verification of the ease-of-use and perceived usefulness of the students' selected service-oriented interfaces (as opposed to course-based) for the mobile LMS interface. This completed the answer to research question (iii), which is: *"How can we partition the services of an LMS for accessibility through mobile computing devices such as mobile phones?"*

Secondly, the findings of the evaluation were useful in answering research question (iv) of this study, which is: *"Does enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces have any impact on the students' access behaviours/patterns of the LMS services?"*

The mVula application was implemented and evaluated through two prototypes. The first prototype of mVula was evaluated for usability, specifically the ease-of-use and perceived usefulness of the application. This involved three separate processes: an expert evaluation, which involved five (5) HCI experts; a focus group evaluation, which involved 11 students, and user experience evaluation, which involved 30 students. The feedback obtained through each of these processes was used to improve the application, leading to the second prototype of mVula. The second prototype was then implemented and an impact evaluation carried out through a longitudinal study (five weeks), in which 37 students participated.

Through the usability and impact evaluation of mVula, conclusions about the overall impact of the intervention in relation to the research objective were also drawn, and these are presented in the next chapter (Chapter 6). Some of the results of the evaluations of mVula have also been presented in a paper titled *"A Streamlined Mobile User-Interface for Improved Access to LMS Services"* (Ssekakubo et al.2014).

This chapter has three sections: Section 5.2 presents the process and results of the usability (ease-of-use and perceived usefulness) evaluation of mVula; Section 5.3 presents the process and results of the impact assessment of the mVula application; and Section 5.4 is the summary.

## **5.2 Evaluating the Ease-of-Use of mVula and Perceived Usefulness**

Ease-of-use, as an attribute of usability was evaluated using standard usability evaluation procedures for ease-of-use (Nielsen and Mack 1994), which were complemented with case-specific measures. According to the standard on Human-Centred Design Processes for Interactive Systems (ISO 13407 and ISO 9241), usability is generally defined as the ‘extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use’. Furthermore, the ISO 9241 standard on usability defines effectiveness as the accuracy or completeness with which users achieve specified goals, while efficiency is defined as the expenditure of physical and mental resources with which users achieve specified goals. It concerns time and the physical effort that needs to be spent to successfully complete the given task. Satisfaction is defined as the level of comfort when using the tool, and is measured as the user's attitudes (positive or negative) towards the tool.

While the focus of usability evaluation of mVula was on the ease-of-use of the application, this could not be evaluated sufficiently without looking at the effectiveness and efficiency of the application as well as the satisfaction of the students with the application. In this case, the main consideration of effectiveness was the ability of the student to complete a given task successfully using the mVula application, while with efficiency, as was done in a similar study by Hakkila *et al.* (2005), physical effort was measured as the number of times of re-doing some basic actions and consulting or asking for advice while using the application. Both of these were achieved through focus group evaluations where the students were asked to interact with, and use the application in presence of the researcher. The measurement for satisfaction was based on the feedback given by the students, both verbally and through an online questionnaire.

In addition, other usability attributes such as suitability for learning; self-descriptiveness; conformity with user expectations; error tolerance and learnability were also evaluated. These were adopted from the ISO Metrics questionnaire (Gediga *et al.* 2000).

In addition to the ease-of-use, this evaluation was also useful in verifying the selected optimization approach of Vula and testing for the feasibility of the ideas presented in the mVula application. The feedback from this evaluation was intended to guide further development of the mVula application. The overall goal was to have mobile LMS interfaces that would eventually compel the students to use their mobile phones to access the LMS services.

The ease-of-use evaluation of mVula was conducted through three processes: expert evaluation; focus group evaluation and user experience evaluation as described below.

### **5.2.1 Evaluating the Ease-of-Use of mVula Through Expert Evaluation**

The expert (sometimes known as heuristic) evaluation of the mVula application was done with a team of five human-computer interaction (HCI) experts and practitioners. These were identified and recruited from graduate students at the Department of Computer Science, University of Cape Town, who had studied human-computer interaction and had practical experience in HCI related studies. The researcher met with each of the experts in a laboratory environment. The experts were asked to interact with use the application for various tasks to examine the application interfaces and judge its compliance with recognized usability principles – the “heuristics” (Nielsen, 1992; Nielsen 1994). Specifically, each of the experts evaluated the mVula application for: simplicity; errors; comprehensibility and flexibility of use; as well as identifying any HCI related concerns and interface flaws to improve user interaction.

Feedback from the experts was mainly verbal and was noted by the researcher and used to improve the application. Table 5.1 highlights some of the issues that were identified by the experts that needed to be addressed in the application in order to enhance user satisfaction.

Table 5.1: Highlights of the feedback from HCI experts on mVula

- Include an "About" tab on the login page of the application within which to give a brief description of the application. *(Done)*
- Turn off text prediction at login. *(Done)*
- Remove the bread crumbs, as they make the application look congested. Keep only the “Home” tab on all screens, to provide consistency in navigation. No need for back button in the application; the device/system back button will be sufficient. *(Done)*
- Make links look clickable, and provide visual feedback when an item is selected. *(Done)*
- Have to indicate where you are all the time in the application—as it is done in announcements. Replicate it for resources and other services. Also indicate the source of the announcement and assignment, given that these are not grouped according to courses. *(Done)*
- Show the file type (mime type) of the resources and other downloadable files (metadata). *(Done)*
- When system times out, and requires a fresh login, it should automatically go to the login page. *(Not implemented. The user would refresh manually to re-login)*
- Where text is longer than screen, use ellipses ... *(Done)*
- The different colours used for the different service-blocks could distract the user. *(Done—all services-blocks were made blue, a familiar dominant Vula website colour)*
- Allow more user control and freedom, i.e. provide ‘emergency exits’ or easier navigation forward and back. *(Done— home button put on every page, and a button for ‘one step back’)*

Overall, from the heuristic evaluation, the interface layout and concepts in mVula were described by the experts as appropriate and that the information appeared in a logical order. The application was also found to be intuitive, allowing the users to recognise what they wanted to do rather than requiring them to recall from previous experiences. The experts also described the ideas presented in mVula as viable and, to the largest extent, the application met standard HCI requirements. After addressing the issue that are highlighted in Table 5.1, the application was evaluated with students in focus groups as described below.

### 5.2.2 Evaluating Ease-of-Use of mVula Through Focus Group Evaluation

The focus group evaluation was carried out with real users who were university students recruited from the University of Cape Town. As mentioned in Chapter 3, ethical clearance (Appendix 3.2) was obtained to allow this study be conducted with the students at the University of Cape Town. The focus group evaluation participants were randomly recruited from the University campus and they had to fulfil two requirements:

- i. Not from the Department of Computer Science (this was because the voluntary user-experience evaluation was planned to be done in the Department of Computer Science); and
- ii. To have a smartphone, preferably not a Blackberry (this was because the native browser and the underlying browser engine of the older versions of Blackberry phones wouldn't access the application).

Once a student fulfilled the two requirements, he/she was recruited and was promised an incentive in the form of airtime, which would be given at end of the evaluation exercise.

According to Dumas and Redish (1999) and Preece *et al.* (2002), five (5) to twelve (12) users are considered an acceptable number for an ease-of-use evaluation study. Preece *et al.* (2002) further suggests that in case of budget and schedule constraints, it is also possible to use fewer users and obtain meaningful results. In this study, 11 students were recruited to participate in the focus group ease-of-use evaluation of mVula. After these were recruited, evaluation meetings were organised with them in groups of 2s and 3s in a controlled environment (lab). Each meeting lasted 15-20 minutes. In the evaluation meetings, the students were briefed about the intention and functionality of application. They were then given a set of tasks (pre-prepared) to accomplish using the application on their mobile phones. The tasks required them to login into the application, navigate through the menus to search for information and to use the interactive features of the application. Figure 5.1 below shows students participating in the focus group evaluation of mVula.

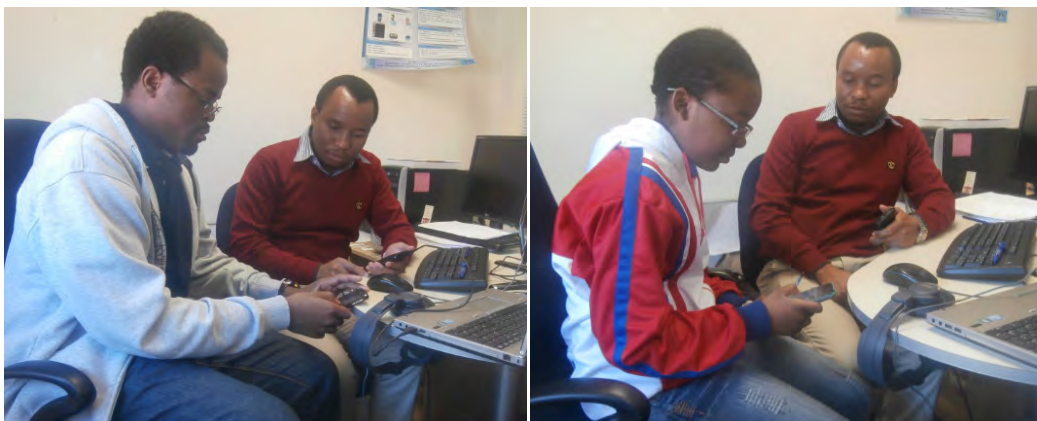


Figure 5.1: Students participating in the focus group evaluation of mVula

The students who participated in the focus group evaluations had varying types of smart and feature phones including Nokia, Android phones and iPhones (Figure 5.2). Some students



used the university Wifi while those whose phones couldn't connect to the Wifi (for varying reasons) used their data bundles, for which they were compensated.

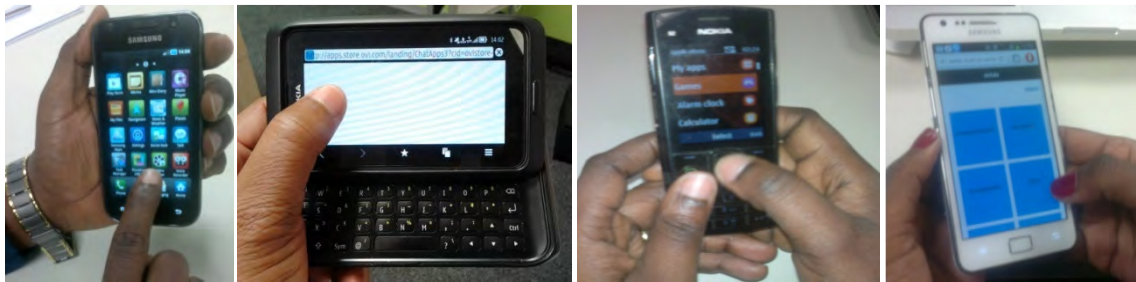


Figure 5.2: Sample of the different phone types used by the students in the usability evaluation of mVula

During the exercise, the students were encouraged to think aloud and their comments were noted (Nielson, 1994; Cotton and Gresty, 2006; Johnstone *et al.* 2006). The think aloud method made it possible to discover what the students really thought about the ideas presented and the design. In particular, their misconceptions were noted, and these turned into actionable redesign recommendations. For instance, where the students misinterpreted design elements, these had to be changed.

After completing the tasks and providing oral feedback about the application, the students completed an online questionnaire that further charted their opinions on the tool and the modalities and, their ideas for further development. The questionnaire took five to eight minutes to fill. This online questionnaire (Appendix 5.1) would later be used during the voluntary user experience evaluation, so its use here was mainly intended to pre-test it.

The focus group evaluation was mainly intended to evaluate the learnability of the application as well as to identify any functional errors and flaws that could have skipped the attention of the expert evaluators. Learnability was assessed with two measurements:

- i. The ability to use the application without instructions/guidance on the first try, and
- ii. Task completion without errors or getting frustrated.

The measurements were based on usage monitoring through direct observation of the students while using the application as well as oral and written feedback from the students during and after using the application. Using the feedback obtained, the mVula application was further improved. Actionable points from the focus group evaluation included: improving the application navigation, re-ordering content (for example assignments) according to posting date and authentication issues (for example some students experienced “login failure”). The

questionnaire (Appendix 5.1) was also improved. For instance, some questions that were found not to be clear to the students were re-worded, while others were eliminated and replaced with other questions. After the focus group evaluation, and the subsequent improvement of the application, the application was then rolled out for user experience evaluation.

### **5.2.3 Evaluating the Ease-of-Use of mVula Through User Experience Evaluation**

As opposed to the focus group evaluation where the students used the application in a laboratory environment while being observed by the researcher, the user experience evaluation involved the use of the application on a voluntary basis by the students in their own niches.

The ISO FDIS 9241-210 defines user experience as “a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service”. Bevan (2009) adds that user experience can be measured during or after use of the product, system or service. In view of that, the mVula application was rolled out to the students, who were allowed to use it for a period of three weeks before the evaluation was conducted.

The user experience evaluation for ease-of-use of mVula was done with students in the Department of Computer Science, University of Cape Town. The department of computer science was selected because it is one of the departments with more activity on the Vula LMS (according to the user log data provided from the Vula server). The already relatively high students' activity on Vula ensured that the students would probably use the mVula application in accessing the Vula services and provide important feedback about the usability of the application. Verbal announcements were made in second and third classes inviting students to participate in the evaluation. Seventy (70) students volunteered to participate and these were registered (email and telephone contacts). The application Web address was sent to the students' email addresses and the students were asked to voluntarily use the application in accessing the Vula services on their mobile phones for about 2-3 weeks and thereafter provide feedback about the ideas presented in the application, ease-of-use and usefulness. On the login page of the mVula application, there was a link to the online questionnaire (Appendix 5.1), which the students had to use to evaluate the application.

The questionnaire had two sections. Section one required the users to evaluate the application in terms of ease-of-use and perceived usefulness of the mVula features and desirability of application use and overall acceptance (satisfaction). These were probed through Likert-type

questions. Section two was the narrative section, which required the users to comment on the application as well as define/mention any other requirements that would make the application more useful to them.

After the three weeks, the students were reminded to provide their feedback. This was done by sending the online questionnaire link to them through their e-mail addresses. Out of seventy (70) evaluation requests that were sent out to the participants, thirty (30) valid responses were obtained (representing a response rate of 44%), and these were analysed.

The presentation and analysis of the collected data was divided into Likert-type responses and the narrative. The Likert-type responses have been analyzed as ordinal data while the narrative data has been organized thematically.

### **Analysis of the Likert-type Responses**

Likert data can either be of Likert-type or Likert-scale. Clason and Dormody (1994) described Likert-type items as the form of the original Likert (Likert, 1932) response alternatives that are considered and analysed as individual questions (not summated). In the Likert-type, multiple questions may be used in a research instrument, but the responses from the items may not be combined into a composite scale (Boone *et al.* 2012). That is, Likert-type questions are unique and stand-alone. Boone *et al.* (2012) further argues that, because Likert-type responses express “a greater than” relationship without indicating by how much, the analysis of such data is often limited to ordinal procedures. Methodological and statistical texts recommend that, for ordinal data, the median or mode should be employed as the measure of central tendency, and frequencies (or percentages) as the measure of variability (Clegg, 1998; Blaikie, 2003; Jamieson, 2004; Boone *et al.* 2012;). This is because the arithmetic manipulations required to calculate the mean, standard deviation and some parametric tests are inappropriate for ordinal data, where the numbers generally represent verbal statements (Jamieson, 2004).

In this study, Likert-type questions with five response alternatives (for example strongly agree, agree, neutral, disagree and strongly disagree) were applied in the evaluation of the ease-of-use of the application, the usefulness of mVula features, and the students’ level of acceptance/satisfaction of the application. Several similar studies (such as: Kwang and Grice, 2004 and Tsai *et al.* 2007) have used this evaluation technique.

The results of the user experience evaluation of mVula are presented below. These further provided insights into the students' expectations of mobile LMS interfaces. The findings were also used to further improve the application before it was rolled out for an impact evaluation.

### 5.2.3.1 Students' Ease-of-Use and Perceived Usefulness of mVula

To evaluate the students' perceived usefulness and ease-of-use of the mVula application, seven questions were asked. Table 5.2 below presents the questions and how the students responded to the each of the questions.

Table 5.2: Likert-type responses on the ease-of-use and perceived usefulness of the mVula application

	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
1	<i>Interaction with mVula is clear and understandable</i>	33.3% (n=10)	36.7% (n=11)	20.0% (n=6)	6.7% (n=2)	3.3% (n=1)	n=30
2	<i>mVula Application is:</i>						
	Easy to use	60.0%(n=18)	33.3%(n=10)	6.7% (n=2)	0.0%(n=0)	0.0%(n=0)	n=30
	Navigable	50.0%(n=15)	30.0%(n=9)	13.3%(n=4)	6.7%(n=2)	0.0%(n=0)	n=30
	Intuitive	23.3% (n=7)	46.7%(n=14)	30.0%(n=9)	0.0%(n=0)	0.0%(n=0)	n=30
	Attractive	10.0% (n=3)	26.7%(n=8)	33.3%(n=10)	26.7%(n=8)	3.3%(n=1)	n=30
3	<i>I find it useful to use my mobile phone to access some services of Vula</i>	60.0% (n=18)	33.3% (n=10)	3.3% (n=1)	3.3% (n=1)	0.0% (n=0)	n=30
4	<i>These mVula features make it easier to access Vula via a mobile phone</i>						
	Having only a few options/services.	36.7% (n=11)	36.7% (n=11)	16.7% (n=5)	6.7% (n=2)	3.3% (n=1)	n=30
	Using block-based interfaces for the services.	30.0% (n=9)	33.3% (n=10)	36.7% (n=11)	0.0% (n=0)	0.0% (n=0)	n=30
	Merging Information from across courses.	60.0% (n=18)	26.7% (n=8)	13.3% (n=4)	0.0% (n=0)	0.0% (n=0)	n=30
5	<i>mVula influences me to access Vula more often</i>	23.3% (n=7)	50.0% (n=15)	23.3% (n=7)	3.3% (n=1)	0.0% (n=0)	n=30
6	<i>mVula enhances my learning effectiveness:</i>						
	in class	16.7% (n=5)	33.3% (n=10)	46.7% (n=14)	3.3% (n=1)	0.0% (n=0)	n=30
	outside class	30.0% (n=9)	40.0% (n=12)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30
7	<i>mVula saves me the need for a computer all the time I need to access information on Vula</i>	43.3% (n=13)	43.3% (n=13)	6.7% (n=2)	6.7% (n=2)	0.0% (n=0)	n=30

Question one was intended to find out whether the ideas presented in the mVula application were clear to the students. According to the responses, at least 21 students (70% of the respondents) agreed that interaction with the application was clear and understandable. That is, that the ideas presented in the application were well understood by the students.

Question two evaluated four usability aspects of the application: Ease-of-use; navigation; intuitiveness; and attractiveness. The responses indicated that, over 80% of students at least

agreed that the application is navigable and easy to use while the rest of the students had neutral responses except two (2) students (6.7%) who indicated that the navigation of the application was still a problem. On the attractiveness of the application interfaces however, only 36% of the students were at least in agreement, while 33% were neutral and 30% were in disagreement. In the narrative section of the questionnaire the students indicated the reasons for their responses especially where they were less satisfied. These are presented in the next section, and they were useful in improving the application.

On the usefulness of using the mobile phone in accessing some services of Vula, over 90% of the students were in agreement. That is, that the idea of accessing Vula services through streamlined mobile interfaces was very useful to the students. The students were able to get the information they needed from Vula via mVula without the need for full desktop interfaces.

Question four was intended to evaluate the perceptions of the students about some of the ideas presented in the mVula application: having only a few options/services; using block-based interfaces for the services; and merging information from across courses. Merging information from across courses into the services was the most liked by the students. Over 80% of the students were at least in agreement that this feature made it easier to access Vula services on the mobile phone, 13% registered neutral responses, while none disagreed. On having a few services of Vula on mVula, 73% of the students agreed that this feature made it easier to access Vula services on the mobile phones while 63% of the students indicated that they liked the block-based interfaces. Although the majority of the students were at least in agreement with the all the three mVula features in making it easier to access Vula services on the mobile phones, their responses indicate that the importance of the three features is in the order: merging information from across courses; having only a few services; using block-based interfaces for the services. In question five, 73% of students re-affirmed that indeed mVula influenced them to access Vula services more often on their mobile phones.

As shown in Table 5.2, the question about the effectiveness of the mVula application registered the highest percentage of neutral responses. This was probably because the students had no idea on how to evaluate the effectiveness or were not in position to judge this effectiveness within a period of three weeks. This attribute was assessed further in the longitudinal impact evaluation.

Overall, over 80% of the students indicated that the mVula application saved them the need for a computer all the time they needed to access information on Vula.

### 5.2.3.2 Students' Satisfaction with mVula

The overall acceptance (satisfaction) of the mVula application was probed through a five-point Likert-scale: highly satisfied; satisfied; partially satisfied; not satisfied; or not at all satisfied. All students who participated in the evaluation indicated that they were at least partially satisfied with the application (Table 5.3).

Table 5.3: Overall acceptance/satisfaction of the mVula application

Question	Highly Satisfied	Satisfied	Partially Satisfied	Not Satisfied	Not at all Satisfied	Total
<i>What is your overall satisfaction with the ideas presented in mVula?</i>	26.7% (n=8)	43.3% (n=13)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30

However, although none of the respondents was “not satisfied”, almost a third of the respondents (30%) were only partially satisfied. This, therefore, meant that more work had to be done on mVula to create greater satisfaction. It was therefore important to carefully analyse the students' comments in the narrative part of the questionnaire so as to identify the causes of the partial satisfaction of the students. These were then used as action points to improve the application and increase students' satisfaction. The next section presents the major highlights of the students' comments in the narrative section of the questionnaire.

### Analysis of the Narrative Responses

The written comments from the narrative section of the questionnaire were analysed using content analysis techniques as described by Rene and Taylor-Powell (2003). The narrative section had open-ended questions that attracted written comments which ranged from brief phrases to full paragraphs of text. The researcher read through the students' comments and identified two coherent categories of the comments: Additional services and requirements for the mVula application and, required improvements in the mVula application to enhance students' satisfaction

### 5.2.3.3 Students' Additional Services and Requirements for the mVula Application

- i. In addition to the provided services, the students requested for more e services, to be added to the application, mainly, Grade book and Tests & Quizzes.
- ii. Enable assignment submission using the phone. Some students requested that the application should allow them to make submissions, especially assignments.

- iii. Notifications for new posts such as new announcements and reminders for assignment deadlines.

#### ***5.2.3.4 Students' Required Improvements in the mVula Application to Enhance User Satisfaction***

- i. Given that the application pulled all the announcements from across all the courses and presented them according to date, the students commented that it was difficult for them to determine which announcement is for which course by simply looking at the announcement caption. So they required that the source of the announcement be indicated as part of the announcement caption. The same also applied to the assignments.
- ii. Most current courses should be displayed first (or courses should be ranked on the screen according to the users' preference).
- iii. Some students commented that the colours used and the overall visual appeal of the interfaces was quite dull, and buttons seemed too big to fit on some screens. Best practices of visual presentations have been consulted and the colour scheme improved.

Overall, there were no major problems identified by the students with the mVula application during the user experience evaluation. There were more positive comments from the students, most of whom seemed happy to use the application in the current state. However, there was need to address some of the usability concerns that were raised by the students in the comments section of the evaluation questionnaire in order to increase their satisfaction with the application.

#### **5.2.4 Addressing the Students' Requirements and Other Usability Concerns of mVula**

Through the user experience evaluation of mVula, the students defined additional requirements and services (as presented in the sections 5.2.3.3 and 5.2.3.4 above) to be added to the mVula application in order to enhance its usefulness to them. Some of the additional requirements and services as defined by the students needed to be developed and implemented in the application while others imply required an improvement in the navigation and visual appeal of the interfaces. For example the display of the announcements and assignments was improved – the captions of the announcements and assignments are displayed with title and source (course) and, they are arranged according to date.

Additionally, the priority in course listing was also changed, the courses appear according to the date of course registration. That is, the current semester courses are listed first, and then the older/previously registered courses follow. About the colours that were used in the application interfaces, best practices of visual presentations were consulted and the colour scheme was improved and, the overall visual appeal of the interfaces was improved.

About the need for more services to be added to the application, the original idea of the application was to provide a few services, given the limitations of the mobile phone. Eight services were provided, and these had been identified as the most needed/required services. These services were thus maintained in the application. However, it is important to note that in some situations, the most needed/required LMS services seem to change with time. For example, given that the user experience evaluation was conducted during mid-semester examinations period, the students seemed to use the Grade book service more often than they had previously ranked it. Also not implemented was the need to enable submission of the assignments in the mVula application. Although this requirement could possibly be implemented across platforms, the students would still be advised that the use of the mobile phones to access Vula services cannot be used as a surrogate for computers, so to perform some tasks such as attaching and sending files would better be done using more appropriate devices, such as PCs and laptop computers.

Among the new requirements defined by the students, was also the need for a notification service to pop up notifications for new posts such as new announcements and reminders for assignment deadlines. This requirement was highlighted by the majority of students. The notification function could however not be implemented as across platform application given that it required the use of smartphone features that are supported differently for each platform. To test the feasibility of this requirement, however, a notification services was developed for one of the platforms, the Android platform, given that the majority of students possessed Android devices. The Android notification service was developed and was integrated into the mVula application. The service connects to the Vula server and runs in the background of the phone and notifies the user of any new postings. The development and functionality of the notification service is further described in the sub-section below.

#### ***5.2.4.1 The mVula Notification Service***

For the purpose of this study, the notifications service was developed for the Android platform. The application service is native, and has to be installed on the phone. It runs as a



separate application and requires the user to login on startup using the Vula login credentials. These credentials are used to make service calls to mVula to poll for various information about the logged in user. The application makes a service call to Vula every 60 seconds (this can be changed). The service returns the users' latest posting. For this study the notification service was implemented for assignments and announcements. The service returns a notification for the latest assignment and announcement. It refreshes after every 60 seconds. If the latest (topmost) assignment and announcement are known to the application then there is no notification served to the user. However, if the user has a new announcement or assignment posted to Vula then the user will be notified via Android's notification manager. The user can either clear the notification or act upon the notification by tapping/clicking on it. The notification will then open the Android device's default browser with the appropriate mVula URL attached to it.

The mVula Android service has three stages: login, user logged screen and background polling. The login screen asks the user for their Vula credentials. It is a simple login UI with an "OK" button for submission of the credentials. The login screen then activates the next activity which is the logged screen. The logged screen serves to inform the user that they are currently logged in to mVula. By pressing "OK" on this logged screen, it starts the activity that polls the mVula service. The background polling service is an Android service (process) that periodically (every 60s) checks to see if the user has a new assignment or announcement. This service is also responsible for serving user notifications.

Had time and resources allowed, a similar service could be developed for the other mobile platforms.

### **5.3 Impact Evaluation of mVula**

Having evaluated the ease-of-use of the mVula application, through which some usability and other additional requirements were identified and addressed, the application was then ready for an impact evaluation. The application was thus deployed for a longitudinal impact assessment.

The mVula impact evaluation was aimed at answering research question (iv), which is: *"Does enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces have any impact on the students' access behaviours/patterns of the LMS services?"*

The students who participated in the impact evaluation (at the University of Cape Town) were recruited from classes and at the university campus (through the help of a research assistant). Although this study did not come across literature that suggests precisely the optimum number of participants required for a longitudinal impact assessment of human-computer studies/interventions, similar studies were found to have used participants in the range of range of five (5) to thirty (30). For example, Kjeldskov and Skov (2005) used seven (7) participants, Mahmud *et al.* (2007) used 10 participants, Gonzáles and Kobsa (2003) used five (5) participants and, Saraiya and Duca (2004) used 30 participants. As a best practice, this study opted to use 30 participants. However, in anticipation that some participants would probably drop-out (Jain *et al.* 2010), the study aimed at recruiting more than the targeted number of participants.

Overall, a total of sixty-seven (67) students were recruited. During the recruitment exercise, the students were briefed about the evaluation process, including seeking their consent (consent form – Appendix 5.2) to have their activities on Vula monitored during the evaluation period. Also, during the recruitment exercise, each of the participants was randomly assigned to a randomised block group (Table 5.4). The students had and used their own mobile devices.

Table 5.4: Randomised blocks for mVula and full Vula mobile interface use during the impact evaluation of mVula

	<b>Week 1</b>	<b>Week 2</b>	<b>Weeks 3,4 and 5</b>
<b>Group1</b>	mVula	Full Vula Mobile Site	Either mVula or Full Vula Site
<b>Group2</b>	Full Vula Mobile Site	mVula	

The randomized block design shown in Table 5.4 ensures that each group has an equal opportunity of receiving a particular treatment and reduces the chance of systematic differences between the groups (Addelman, 1969). In this case, it ensured that all the participants were familiar with, and had used the streamlined mVula application and the full Vula mobile interface so that in the end they would be able to compare and evaluate the ideas presented in mVula. This also helped to minimize bias because all the participants were equally exposed to all the interfaces.

Group one was asked to use the mVula application (on address: <http://simba.cs.uct.ac.za/mVula/>) to access Vula services on their mobile phones for one week while group two was asked to use the full Vula mobile interface (on address: <https://Vula.uct.ac.za/portal>) to access Vula services during the same week. After the one

week, the first group was then asked to use the full Vula mobile interface and the second group was asked to use the mVula application (Table 5.4). The links to the sites and additional instructions were sent to the participants through their e-mail addresses.

In the third, fourth and subsequent weeks, the participants were asked to continue accessing Vula through mobile phones using either mVula or the full Vula mobile interface, depending on their preference (Table 5.4).

At the end of the fifth week, evaluation data in the form of students' self-reports (through an online questionnaire) and Vula usage log data were obtained and analyzed. This method is supported by Jain *et al.* (2010) who argued that user response data after using an application and usage logs are the most ideal methods for assessing impact in longitudinal investigations. The analysis of the collected data was guided by the following specific questions (which, collectively helped to answer research question (v) of this study):

- I. To what extent are the students satisfied with the mVula features?
  - a. Does the streamlined mobile user interface with fewer Vula services and a block-based interface layout give more satisfaction to the students than the more elaborate mobile interface with all services?
  - b. Does the idea of merging information from across the courses into a service (e.g. announcements) give more satisfaction to the students than having to look for such information per course?
  - c. Is the integration of platform-specific functionalities such as the notifications feature into a mobile LMS interfaces worthwhile? To what extent does the notification feature influence the students' behaviour in accessing Vula services on their mobile phones?
  - d. Do the students' Vula access behaviours change as a result of the availability of the mVula application?
- II. How does the mVula intervention affect the usage patterns of Vula?
  - a. How often do the students access Vula using mVula compared to the full Vula mobile interface? And how do the user access statistics for both interfaces change with time?
  - b. What time of the day do the students mainly use the mVula application in accessing Vula services?

- c. On average, how long does each user session on mVula last, compared to the length of user sessions through the full Vula mobile interface or through the direct Vula desktop interface?
- d. Which devices do the students use to access mVula?
- e. Which activities do the students perform on the different Vula access interfaces?
- f. What other patterns can be identified in the accessibility and use of Vula, given the mVula intervention?
- g. Does mVula lead to a greater use of Vula?

To answer the questions above, the next sections present and analyse the data of the students' self-reports and mVula usage logs.

### 5.3.1 Data from the Students' Evaluation Reports/Questionnaires

Questions (1a-1d) were answered using the written feedback obtained from the participants through an online questionnaire (Appendix 5.3). An e-mail containing the questionnaire link was sent out to the students at the end of the fifth week of mVula deployment.

The questionnaire sought to obtain information about: the students' level of satisfaction with the ideas presented in the mVula application; and their self-reported change in access behaviour of Vula services as a result of the mVula intervention. As was done during the ease-of use evaluation, these were probed through Likert-type questions as well as feature rating and narrative questions.

Out of the 67 participants to whom the questionnaire was sent, 44 participants responded (representing a response rate of 66%). However, seven (7) of the questionnaires were partially filled, and these were not included in the analysis. Tables 5.5, 5.6 and 5.7 present a summary of the responses.

Table 5.5: Frequency of Vula access

Question	Responses						Total
	several times daily	about once a day	3-5 days a week	1-2 days a week	every few weeks	Never	
<i>On average, how often do you access Vula?</i>	54.1% (n=20)	27.0% (n=10)	5.4% (n=2)	10.8% (n=4)	2.7% (n=1)	0.0% (n=0)	(n=37)

Table 5.5 above shows that over 50% of the students who participated in the evaluation exercise accessed Vula several times a day, while over 80% accessed Vula at least once a

day. None of the participants never accessed Vula at all during the evaluation period. This means that the Vula access behaviour for all the 37 participants over the evaluation period could be analysed and would be informative of the impact of the mVula intervention on Vula access patterns.

The responses to question two, in Table 5.6 indicate that, although all the students used computers/laptops to access Vula (at least some of the time), over 30% of them accessed Vula through their mobile phones, at least most of the time, and over 80% accessed Vula through their mobile phone, at least some of the time. The majority (73%) never used tablets at all to access Vula services (Table 5.6), this is probably because few students possessed tablets.

Table 5.6 also shows that when the students used their mobile phones to access Vula, 70% of them did so through the mVula application, at least most of the time. Question 3 (b) in Table 5.6 shows that 62% of the students indicated that they never used the full Vula mobile interface to access Vula services; this contradicts the fact that all the students were made to use both of the interfaces during the evaluation period, and the log data shows that the majority of them accessed Vula through the full Vula mobile interface at least once during the four weeks. It was later however realised that this sub-question was misunderstood by the students to have meant the use the full Vula mobile interface before the evaluation period, since the full Vula mobile interface had always been available, though not so popular with the students. This statistic was thus ignored and so the contradiction was cleared.

Table 5.6: Access devices for Vula and mVula

	Questions		Responses					
			All the time	Most of the time	Some of the time	Occasionally	Never	Total
2	<i>When you access Vula, how often do you do so:</i>	<i>a. Using your mobile phone</i>	10.8% (n=4)	24.0% (n=9)	46.0% (n=17)	13.5% (n=5)	5.2% (n=2)	(n=37)
		<i>b. Using a computer/laptop</i>	18.9% (n=7)	51.4% (n=19)	29.7% (n=11)	0.0% (n=0)	0.0% (n=0)	(n=37)
		<i>c. Using a tablet</i>	2.7% (n=1)	2.7% (n=1)	8.1% (n=3)	13.5% (n=5)	73.0% (n=27)	(n=37)
3	<i>When you use your mobile phone to access Vula, how often do you do so:</i>	<i>a. Through mVula</i>	37.8% (n=14)	32.4% (n=12)	21.6% (n=8)	5.4% (n=2)	2.7% (n=1)	(n=37)
		<i>b. Through the full Vula mobile interface</i>	0% (n=0)	5.4% (n=2)	18.9% (n=7)	13.5% (n=5)	62.1% (n=23)	(n=37)
		<i>c. Through other applications</i>	0% (n=0)	0% (n=0)	0% (n=0)	2.7% (n=1)	97.3% (n=36)	(n=37)
4	<i>When you use mVula, how often do you do so using the following devices:</i>	<i>a. Mobile phone</i>	37.8% (n=14)	37.8% (n=14)	18.9% (n=7)	2.7% (n=1)	2.7% (n=1)	(n=37)
		<i>b. A tablet</i>	2.7% (n=1)	2.7% (n=1)	5.4% (n=2)	2.7% (n=1)	86.5% (n=32)	(n=37)
		<i>c. Computer/Laptop</i>	2.7% (n=1)	21.6% (n=8)	8.1% (n=3)	16.2% (n=6)	51.4% (n=19)	(n=37)

Additionally, although the majority (over 70%) of the students indicated to have used the mVula application on their mobile phones, some of them (about 30%) also indicated to have used the application on other devices, notably the computers/laptops, at least some of the time (Table 5.6). This means that, even with streamlined mobile LMS interfaces, students still need the computers/laptops to access the LMS at least some of the time.

The impact evaluation reports also indicated an increase in the students' appreciation of the mVula features compared to the first user experience evaluation that was conducted in the ease-of-use evaluation. For example, over 77% of the students agreed that having only a few services of Vula (the most needed/required) and merging information from across courses (e.g. announcements) made it easier for them to access Vula on their mobile phones (Table 5.7). Seventy percent (70%) agreed that the 'service-based' feature of mVula as opposed to traditional 'course-based' interfaces of the LMSs made it easier to access Vula services on the mobile phones (Table 5.7).

Table 5.7: Features and usefulness of mVula

Questions			Responses					
			Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
5	<i>These mVula features make it easier to access Vula via a mobile phone</i>	<i>a. Service- based, as opposed to being Course-based</i>	18.9% (n=7)	51.3% (n=19)	10.8% (n=4)	16.2% (n=6)	2.7% (n=1)	(n=37)
		<i>b. Having only a few services of Vula (the most needed/required)</i>	48.6% (n=18)	29.7% (n=11)	21.6% (n=8)	0% (n=0)	0% (n=0)	(n=37)
		<i>c. Using block-based interfaces for the services on initial login</i>	21.6% (n=8)	37.8% (n=14)	27% (n=10)	10.8% (n=4)	2.7% (n=1)	(n=37)
		<i>d. Merging information from across courses(e.g. announcements)</i>	40.5% (n=15)	37.1% (n=13)	5.4% (n=2)	13.5% (n=5)	5.4% (n=2)	(n=37)
		<i>e. The notification service</i>	13.5% (n=5)	5.4% (n=2)	81% (n=30)	0% (n=0)	0% (n=0)	(n=37)
6	<i>With mVula, I am encouraged/influenced to access Vula more often</i>		24.3% (n=9)	37.8% (n=14)	24.3% (n=9)	13.5% (n=5)	0% (n=0)	(n=37)
7	<i>mVula saves me the need for a computer all the time I need to access information on Vula</i>		24.3% (n=9)	40.5% (n=15)	18.9% (n=7)	10.8% (n=4)	5.4% (n=2)	(n=37)
8	<i>mVula enhances my learning effectiveness:</i>	<i>a. in class</i>	2.7% (n=1)	29.7% (n=11)	43.2% (n=16)	18.9% (n=7)	5.4% (n=2)	(n=37)
		<i>b. outside class</i>	10.8% (n=4)	35.1% (n=13)	37.8% (n=14)	10.8% (n=4)	5.4% (n=2)	(n=37)

Over 60% of the students agreed that with mVula they are encouraged/influenced to access Vula services more often and that mVula saves them the need for a computer all the time when they need to access information on Vula. Consequently, the students rated the usefulness of the mVula application highly. Although the question about the usefulness of mVula in enhancing the students' learning effectiveness registered the highest percentage of neutral responses, it is clear that mVula is more useful in enhancing their learning effectiveness outside class than in class. The high percentage of neutral responses for this question was probably because the students could not easily and directly relate the usefulness of the mVula application towards achieving the learning effectiveness. Additionally, as Moody *et al.* (2007) state, learning effectiveness is evaluated in the context of the learning goals of course and in the context of the overall educational programme and future working

life, which could not be measured in this study. In this case, effectiveness could only be measured as a usability attribute (in the form of ease-of-use and perceived usefulness) which is concerned primarily with the functionality of the mVula application, regardless of whether or not the learning objectives are being met (Jenkinson, 2009). This question, therefore, was only useful for revealing that mVula is more useful to the students outside class than in class.

In the narrative section of the questionnaire, insights and explanations by the students about the application and how it could be improved were provided. The most frequent comments have been extracted thematically and are presented in Table 5.8 below. While some comments implied that the students were satisfied with the application, without defining any new requirements, some comments pointed out required improvements in the application. Overall, 11 unique themes were identified from the narrative section of the 37 questionnaires and, these had a combined frequency of 43; this was because some comments embodied more than one theme.

Table 5.8: Main themes in the students' comments during the impact evaluation of mVula

Themes (Identified from comments)	Frequency of comment
Great idea (non-congested, service based, aggregation of information)	15
Provides effective and quick access	3
Notification feature very helpful	2
Another service needed	3
Improve chat room	1
Improve resource access	4
Limited to fewer courses	2
Login failure and service breakdown	6
Missing some features and not accessible on some phones	2
Should remember login credentials	2
Slow in processing and downloading	3

As shown in Table 5.8 above, most frequently, the students' comments indicated that having a non-congested, service-based and aggregated mobile Vula application was a great idea. They also indicated that the application provides effective and quick access to Vula services through their mobile phones, and that the notification feature was helpful. This indeed answers the question whether the streamlined mobile user interface with fewer Vula services give more satisfaction to the students than the more elaborate mobile interface with all



services and that the idea of merging information from across the courses into a service (e.g. announcements) gives more satisfaction to the students than having to look for such information per course. Additionally, the integration of the notifications feature into mVula was found to be useful to the students, although it was not possible to establish the extent to which the notification feature influences the students' behaviour in accessing Vula services on their mobile phones.

However the comments also highlighted the need to improve some existing services, notably the resource and chat services (some students were unable to download the resources), as well as adding a few more services to the mVula application. The students also echoed frustrations about login failure and service breakdown of the application. This was mainly caused by the unavailability of the server due to technical problems. Electricity outage at the university also interrupted the evaluation (although there are always standby generators to power at least the servers in case of electricity outage, sometimes the generators could be out of fuel). Other requirements raised by the students included the need for the application to store the login credentials on first login.

Overall, over 97.3% of the students who participated in the evaluation indicated that they were satisfied with the mVula application. Only one student (2.7 %) was not satisfied and none was 'not satisfied at all'. This shows the extent to which the students are satisfied with the mVula features. In fact, the students mentioned that they wished to continue using the application beyond the evaluation period. The service was left up and running for the students to continue using it.

### **5.3.2 Data from the Vula Usage log Files**

Questions (2a-2g) were answered using the user log data (the session and event logs) obtained from the Vula and mVula servers. This data was critically analysed to identify any patterns in the participants' Vula activities and access behaviours during the five weeks. Baseline data about Vula access by the participants four weeks before the deployment of the mVula application was obtained. The baseline data (Table 5.9) indicates that, on average, 92% of the students' Vula access occurred through computers/laptops and only 8% occurred through the mobile devices.

Table 5.9: Students' Vula access through the the mobile phones and computers, before the deployment of the mVula application

	Frequency	Percentage
Vula access through mobile phones	288	8%
Vula access through computers	3301	92%
Total	3589	100%

As show in Table 5.9 above, before the deployment of mVula, the 38 students had a combined frequency of 3301 of Vula access through computers while their combined frequency for access through the mobile phones was 288. In the subsequent four weeks after the deployment of mVula, the total frequency of Vula access through the mobile phones rose to 1246 for the 38 students while access through the computers dropped to 2790 (Table 5.10).

Table 5.10: Students' Vula access through the the mobile phones and computers, after the deployment of the mVula application

	Frequency	Percentage
Vula access through mobile phones	1246	31%
Vula access through computers	2790	69%
Total	3589	100%

A further analysis of Vula access through the mobile phones (Table 5.11) indicates that out of the 1246 times that the students accessed Vula through their phones, 1069 (85%) were through the mVula interfaces and only 177 (15%) were through the full Vula mobile interface.

A student by student analysis (Table 5.11) of the Vula access during the four weeks of mVula deployment shows that all students clearly preferred the mVula interface to the full Vula mobile interface. However, for the majority of students, significant activity remained on the computers (although for some students had more Vula sessions on their mobile phones than they had through the computers).

Table 5.11: Frequencies of students' Vula access through the various interfaces (platforms) and devices

#	User ID	Frequency of Vula access through mobile phones		Frequency of Vula access through Computers
		Access through mVula	Access through full Vula mobile interface	
1	S1	53	7	51
2	S2	12	2	104
3	S3	20	2	53
4	S4	8	2	77
5	S5	14	3	28
6	S6	21	4	84
7	S7	7	2	65
8	S8	9	2	49
9	S9	18	1	49
10	S10	58	10	49
11	S11	4	2	168
12	S12	87	9	17
13	S13	14	2	82
14	S14	48	11	24
15	S15	13	4	58
16	S16	19	1	0
17	S17	63	15	30
18	S18	34	0	9
19	S19	42	8	124
20	S20	4	0	83
21	S21	47	6	114
22	S22	37	0	49
23	S23	22	1	157
24	S24	19	1	67
25	S25	85	16	50
26	S26	14	1	54
27	S27	67	9	49
28	S28	4	0	109
29	S29	24	7	70
30	S30	2	0	176
31	S31	8	3	45
32	S32	28	6	95
33	S33	24	16	127
34	S34	31	4	34
35	S35	9	1	52
36	S36	26	14	81
37	S37	7	1	129
38	S38	67	4	128
	<b>Average</b>	<b>28</b>	<b>5</b>	<b>73</b>
	<b>Total</b>	<b>1069</b>	<b>177</b>	<b>2790</b>

Overall, the data presented in Tables 5.9, 5.10 and 5.11 shows that: the students preferred the streamlined mVula interface to the full Vula mobile interface (this is also shown graphically in Figure 5.3 below); and the mVula interface influenced the students to access Vula services more often through their mobile phones.

Figure 5.3 shows that each individual who accessed Vula on the mobile phone had more sessions through the mVula interface than the full Vula mobile interface during the four week period.

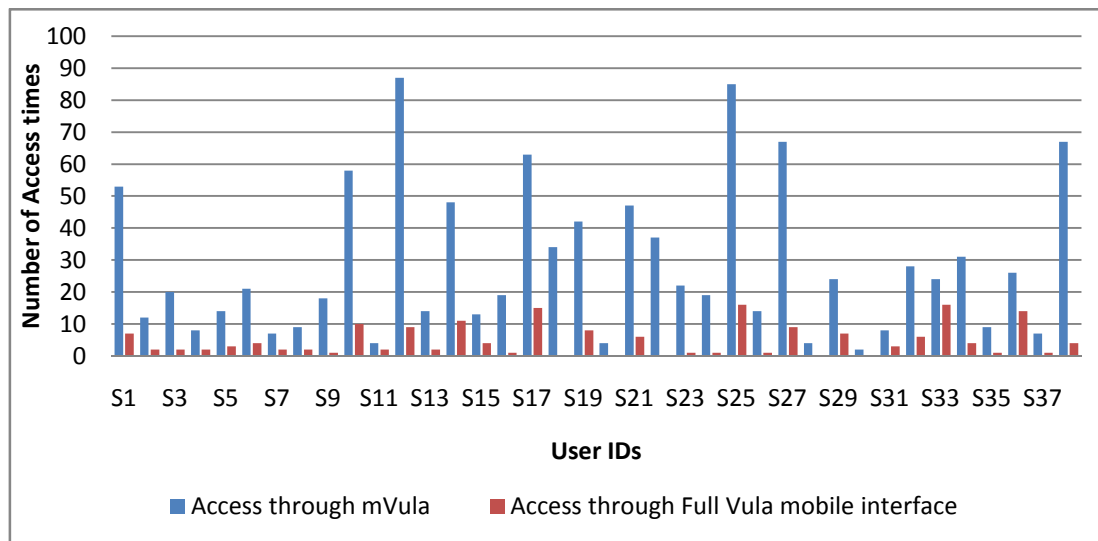


Figure 5.3: Vula mobile access through mVula interface and the full Vula mobile interface for each user

Access through the two different interfaces was calculated based on the number of times the students logged into Vula (user sessions) through each of the interfaces during the four weeks.

An analysis of the daily access of mVula by the students (using the 'session-host-name' attribute of the log data) indicated that the average daily access of Vula through mVula was 40 visits per day (Figure 5.4).

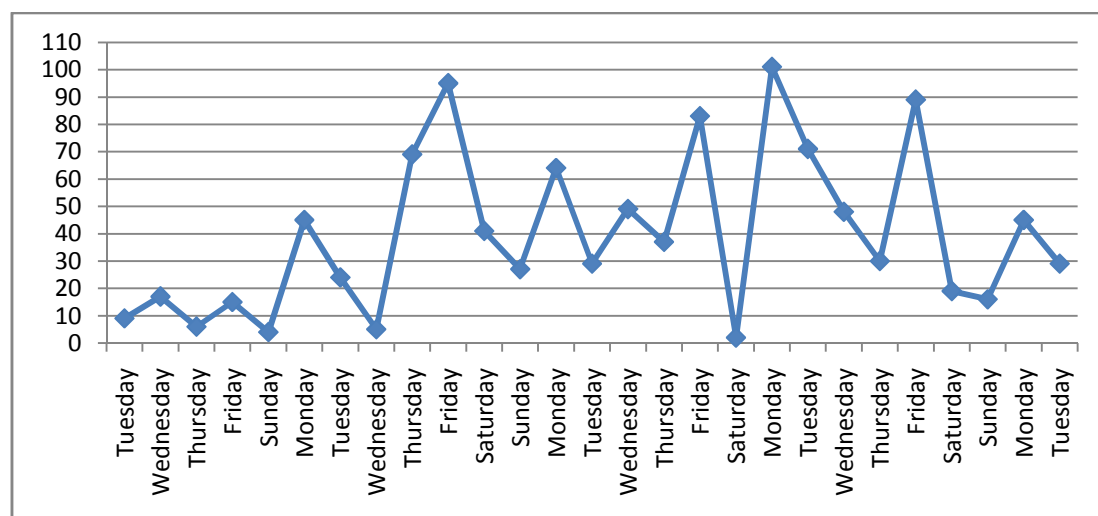


Figure 5.4: Visits to mVula site per day

From Figure 5.4 it is can be observed that there are observable trends in the access of the mVula application for any specific days. The sharp drops (to almost zero) in the access to mVula as observed in Figure 5.4 above, for example on 10-04-2013 (Wednesday) and 20-04-2013 (Saturday), were as a result of the mVula server being off due to technical reasons.

As described at the beginning of section 5.3 (Table 5.4), during the evaluation, the students were divided into two groups: group one was asked to use the mVula application to access Vula services on their mobile phones for one week while group two was asked to use the full Vula mobile interface to access Vula services during the same week. After the one week, the first group was then asked to use the full Vula mobile interface and the second group was asked to use the mVula application. The groups contained equal numbers of students and the students were randomly assigned to the groups (Randomised block design). Consequently, the access of Vula through the two interfaces is also analysed per week to identify any further patterns for each group and between the groups.

Table 5.12 below shows the access of Vula through mVula and the full Vula mobile interface per week of the four weeks and the trends are shown in Figure 5.5.

Table 5.12: Vula access through mVula interface and the full Vula mobile interface per week

	mVula Usage per week	Full Vula mobile Interface Usage per week
Week 1 (day1 –day 7)	51	72
Week 2 (day 8 –day 14)	306	76
Week 3 (day15 –day 21)	264	17
Week 4 (day22 –day 28)	374	10
Day 29 and 30	74	2
Total	1069	177

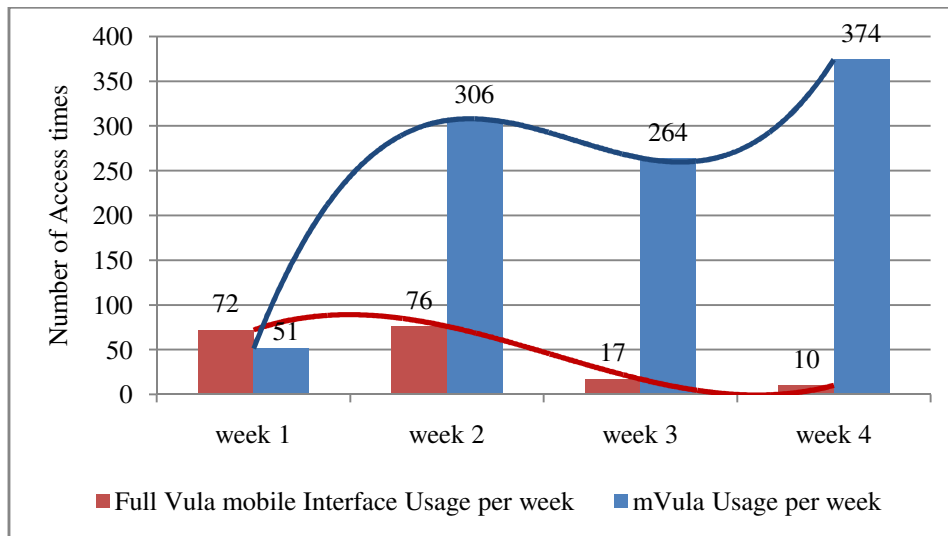


Figure 5.5: Vula access through mVula and the full Vula mobile interface per week

Figure 5.5 and Table 5.12 show that, only in the first week of evaluation, the full Vula mobile interface was slightly used more than the mVula application, after which the use of mVula increased almost spontaneously while that of the full mobile Vula interface decreased. In the first week, the full mobile Vula was used slightly more because some students were already aware of the full Vula mobile interface while the mVula application was new to all the students. Additionally, the mVula application had a relatively longer address (access link) so the students took some time to get used to it. In the second and subsequent weeks the usage of mVula surpassed the usage of the full Vula mobile interface. The usage of the full Vula mobile interface decreased sharply with time as that of mVula increased, meaning that, after gaining familiarity with both interfaces, the students preferred to use the mVula interface.

### 5.3.2.1 Group Analysis

The group analysis (Table 5.13 and Figures 5.6 – 5.9) shows that, generally, there was an upward trend in the usage of mVula by both groups and a downward trend in the usage of the full Vula mobile interface over the period.

Table 5.13: Usage frequencies for the mVula and the full Vula mobile interfaces by the two groups over the four weeks

	Group 1		Group 2	
	use of mVula	use of full Vula mobile interface	use of mVula	use of full Vula mobile interface
Week 1(day1 –day 7)	45	3	6	69
Week 2 (day 8 –day 14)	200	54	106	22
Week 3 (day15 –day 21)	151	10	113	7
Week 4 (day22 –day 28)	173	4	201	6
Day 29 and 30	32	2	42	0

In the first week, group one was asked to use the mVula application while group two was asked to use the full Vula mobile interface in accessing Vula services on the mobile phone. During that week, there was a total of 51 Vula sessions through mVula with only six (6) of them from a user(s) who should have been in group two. In the same week, there was a total of 72 Vula sessions through the full Vula mobile interface, with three (3) of them from a user(s) who should have been in group one. The understanding was that no student from group one would have been expected to use the full Vula mobile interface in the first week, and no student from group two would have been expected to use the mVula interface in the first week. However, it is likely that user IDs for two students were inadvertently interchanged between the groups during data extraction. In the second week group one was asked to use the full Vula mobile interface, which they did with a total of 54 Vula sessions through the full Vula mobile interface for group one. However, the same group also continued to use the mVula interface, registering a total of 200 Vula sessions through mVula. In the same week (second week), group two was asked to use the mVula application, which they did, registering a total of 106 Vula sessions through mVula for group two. However, there were also some Vula sessions (22 sessions) through the full Vula mobile interface for the same group in week two. In the third and subsequent week (s), when the students were not asked to use any interface (that is, they could use any), access through the mVula interface increased while access through the full Vula mobile interface reduced considerably. Figures 5.6, 5.7, 5.8 and 5.9 further illustrate the access behaviour of the two groups for Vula services through the mVula interface and the full Vula mobile interface over the period of four weeks.

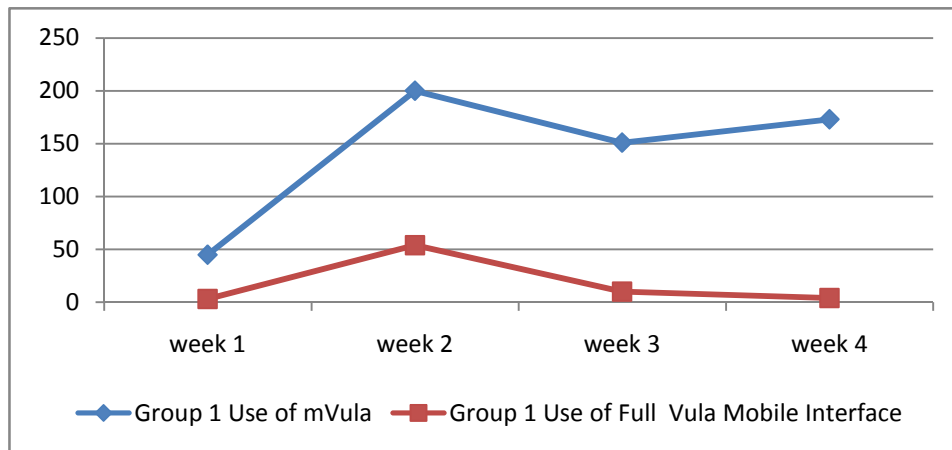


Figure 5.6: Group 1: Use of mVula vs. use of the full Vula mobile interface

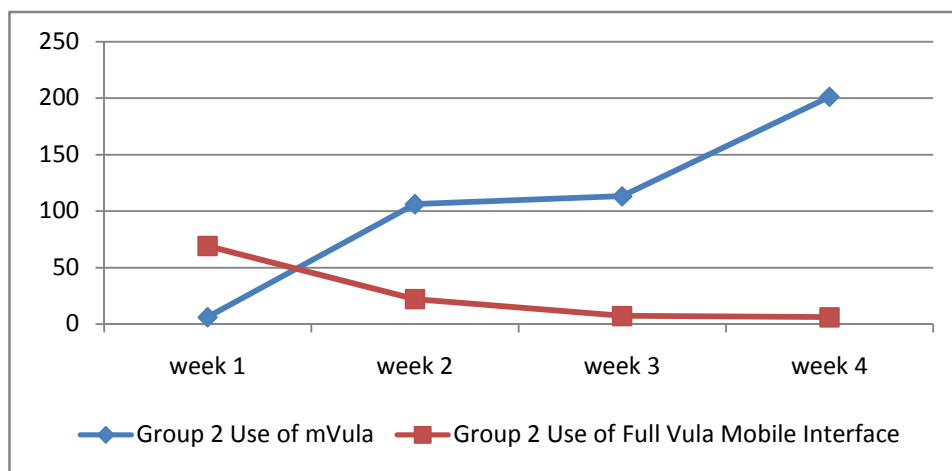


Figure 5.7: Group 2: Use of mVula vs. use of the full Vula mobile interface

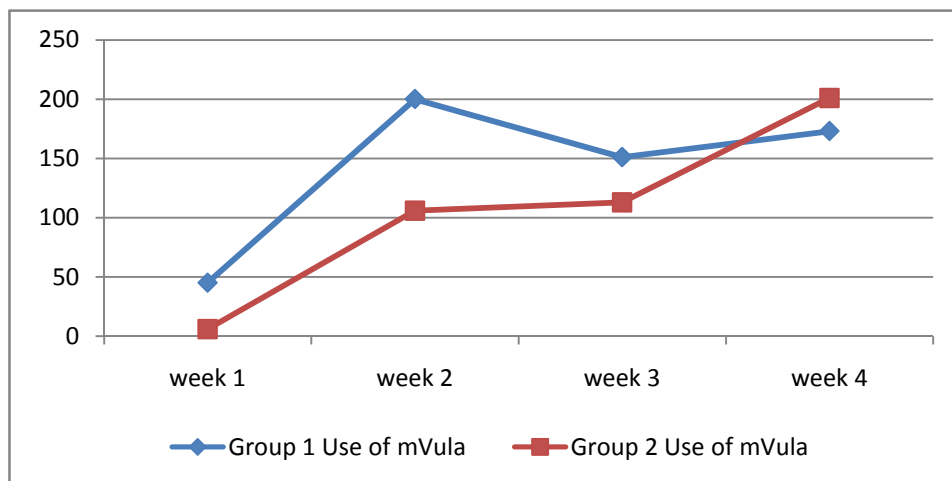


Figure 5.8: Use of mVula: Group 1 Vs Group 2



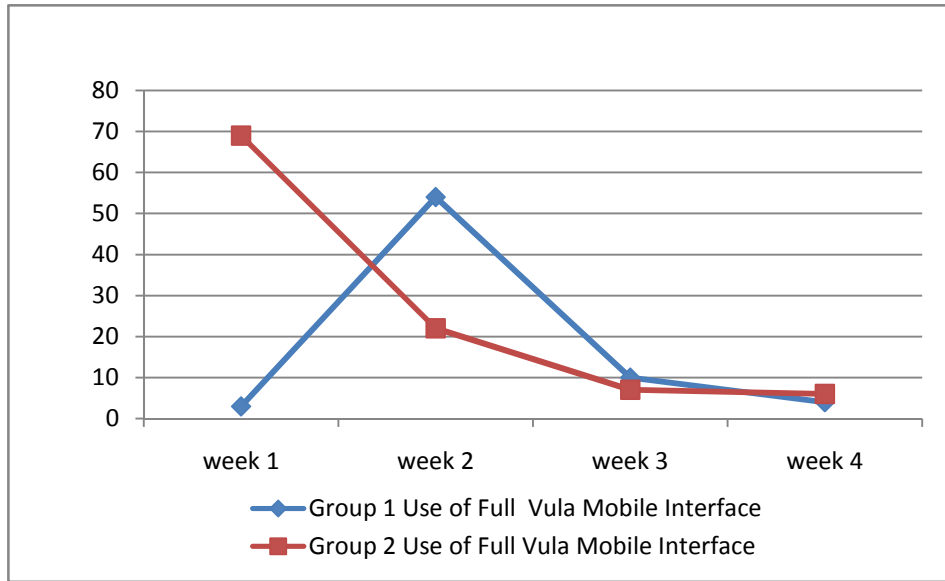


Figure 5.9: Use of the full Vula mobile interface: Group1 Vs Group 2

In the experimental design, while Group 1 were expected to use mVula in the first week, Group 2 were to use the full Vula mobile interface. However, according to Figure 5.8, some students in Group 2 used mVula (as it was difficult to make sure that they should not use it at all), while after week 1 some Group 1 students also continued to use mVula. Most importantly however as shown in Figure 5.9 both Groups also used the full Vula mobile interface. This meant that both groups had an experience with both interfaces in the first two weeks, as it was intended. As shown in Figures 5.8 and 5.9, after the first two weeks, the use of mVula increased while the use of the full Vula mobile interface decreased indicating the students preferred the mVula interface to the full Vula mobile interface.

### 5.3.2.2 Activities and Services Performed Through the Different Vula Interfaces

In each Vula session, the students perform various activities. An activity is defined as a ‘click’ on any clickable item, for example: clicking on a course tab; clicking on a service block such as announcements; clicking to open an actual announcement; and all navigations within the application are considered as activities. The students had different activity counts when using the different devices to access Vula, as well as when using the different interfaces to access Vula on the mobile phones (Table 5.14). As Table 5.14 shows, the students performed more activities when using computers than when using mobile phones. This was because when using the computers (bigger screen and more usable input peripheral devices such as the keyboard or mouse), the students could easily afford to perform extra navigations (clicks) around the application. Moreover, when using the mobile phone (with a smaller

screen and smaller input and navigation keys), the students would perform only the required clicks to get to the information they wanted without ‘unnecessary’ navigations.

However, it should also be noted that some students performed more Vula activities overall on the mobile phones than on the computers because they had more Vula sessions on their mobile phones than on the computers.

Table 5.14: Number of Vula activities performed by the students through mobile phones  
(using mVula and the full Vula mobile interface) and the computers

#	User ID	Vula Activities on Mobile Phones		Vula Activities through PCs/Laptops
		Activities on Vula through mVula	Activities on Vula through Full Vula mobile interface	
1	S1	242	64	819
2	S2	132	21	1575
3	S3	127	24	876
4	S4	98	37	797
5	S5	42	18	866
6	S6	96	42	1348
7	S7	144	56	2927
8	S8	70	18	877
9	S9	115	8	2216
10	S10	345	98	813
11	S11	16	14	584
12	S12	915	93	717
13	S13	212	14	864
14	S14	564	89	468
15	S15	150	16	949
16	S16	162	9	1667
17	S17	375	137	345
18	S18	203	0	159
19	S19	265	67	778
20	S20	14	0	1252
21	S21	501	81	617
22	S22	311	0	1652
23	S23	232	11	87
24	S24	186	15	573
25	S25	659	192	1091
26	S26	206	9	655
27	S27	497	112	830
28	S28	12	0	1403
29	S29	162	49	5
30	S30	6	0	1622
31	S31	24	19	1249
32	S32	178	58	588
33	S33	207	128	567
34	S34	225	31	1352
35	S35	158	11	2232
36	S36	244	134	1073
37	S37	62	12	362
38	S38	501	24	881
	<b>Average</b>	<b>228</b>	<b>45</b>	<b>993</b>
	<b>Total</b>	<b>8658</b>	<b>1711</b>	<b>37736</b>

When using the mobile phones to access Vula services, the students performed more activities with mVula than with the full Vula mobile interface. This was because the students

had more Vula sessions through the mVula interface than the full Vula mobile interface. A total of 8658 activities were performed through mVula, compared to 1711 activities performed through the full Vula mobile interface. On average, 228 activities were performed by each student through mVula, compared to the 45 activities performed through the full Vula mobile interface during the four weeks. However, an analysis of the number of activities performed per session by each student through the two interfaces reveals that more activities were performed per session by the students while using the full mobile Vula interface. The number of activities performed per session is higher in the full mobile Vula interface than in the mVula interface (Table 5.15). On average, ten (10) activities were performed per session in the full mobile Vula interface while eight (8) activities were performed per session in the mVula interface. This means that, while using the full mobile Vula interface, the students required two (2) extra steps than they required when using the mVula interface, to obtain the information they wanted. This means that it is easier to access Vula services through the mVula interface than the full Vula mobile interface. This encouraged the students to use mVula more often to access Vula services on their mobile phones; after all they also spend less of their Internet data bundles.

Table 5.15: Number of Vula activities performed per session

User ID	mVula Sessions	Full Vula mobile interface Sessions	mVula activities	Full Vula mobile interface activities	Activities per session of mVula	Activities per session of full Vula mobile interface activities
S1	53	7	242	64	5	9
S2	12	2	132	21	11	11
S3	20	2	127	24	6	12
S4	8	2	98	37	12	19
S5	14	3	42	18	3	6
S6	21	4	96	42	5	11
S7	7	2	144	56	21	28
S8	9	2	70	18	8	9
S9	18	1	115	8	6	8
S10	58	10	345	98	6	10
S11	4	2	16	14	4	7
S12	87	9	915	93	11	10
S13	14	2	212	14	15	7
S14	48	11	564	89	12	8
S15	13	4	150	16	12	4
S16	19	1	162	9	9	9
S17	63	15	375	137	6	9
S18	34	0	203	0	6	
S19	42	8	265	67	6	8
S20	4	0	14	0	4	
S21	47	6	501	81	11	14
S22	37	0	311	0	8	
S23	22	1	232	11	11	11
S24	19	1	186	15	10	15
S25	85	16	659	192	8	12
S26	14	1	206	9	15	9
S27	67	9	497	112	7	12
S28	4	0	12	0	3	
S29	24	7	162	49	7	7
S30	2	0	6	0	3	
S31	8	3	24	19	3	6
S32	28	6	178	58	6	10
S33	24	16	207	128	9	8
S34	31	4	225	31	7	8
S35	9	1	158	11	18	11
S36	26	14	244	134	9	10
S37	7	1	62	12	9	12
S38	67	4	501	24	7	6
<b>Average</b>	<b>28</b>	<b>5</b>	<b>228</b>	<b>45</b>	<b>8</b>	<b>10</b>

When accessing Vula through the mVula interface, each session lasted an average of two (2) minutes and, on average, two (2) services were accessed during each session. The most frequently visited services were Announcements, Resources and Assignments (Figure 5.10).

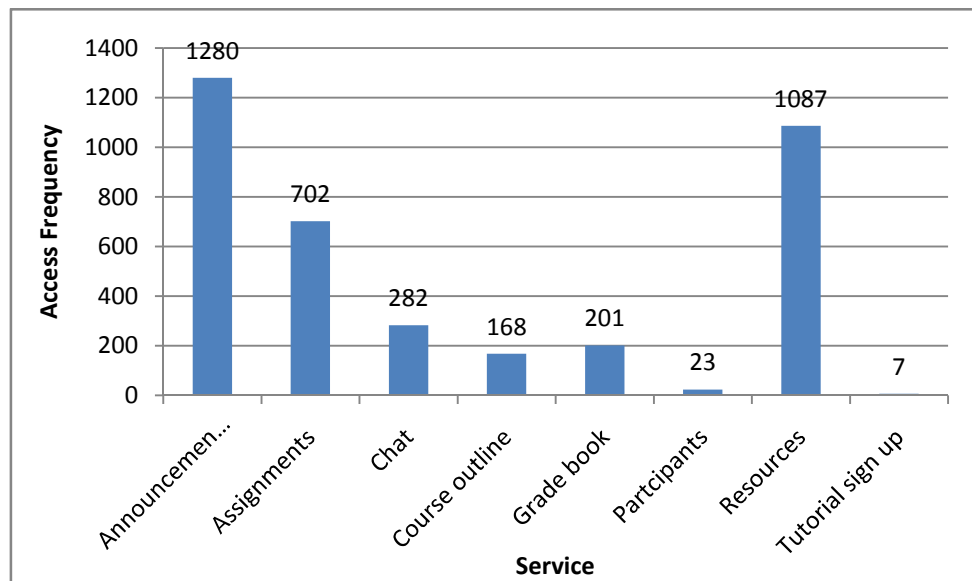


Figure 5.10: Access frequencies of the Vula Services

Figure 5.10 further re-affirms the findings of the survey in which the students indicated that Announcements, Resources, Assignments, Course outlines and Chat room are the most needed/required LMS services.

#### 5.4 Mobile LMS Solutions: Some Lessons for Implementations in Developing Countries

In the developing country universities that were surveyed in this study, the majority of students were found to possess internet enabled mobile phones, which they were using for a range of activities, notably social media. Following the design and implementation of the streamlined mobile LMS interfaces for Vula at the University of Cape Town, the students also more increasingly used their mobile phones to access the LMS services.

The cost of using the mobile phones by the students for various activities including accessing the LMS services are/were met by the students whereby the students use mobile data internet plans to access the internet (with 3G and 4G internet speeds). In some instances, there are some wireless hotspots in the university campus through which the students using mobile phones and other devices can be able to connect to the internet through free university Wi-Fi. This is however constrained by the fact that the universities do not subscribe to sufficient bandwidth to be able to support the increasing need and demand by the students and other users, and only a few areas in the campuses are covered by Wi-Fi. This therefore means that

the most sure and reliable way the students could access internet on the mobile devices is through the mobile data internet plans. Fortunately, with increasing competition among the various mobile service providers, the cost of mobile internet has been going down, and it is expected that it will continue to go down thereby mobile internet access becoming more affordable to more students.

In this study, although the exact bandwidth requirements for accessing the LMS services were not explicitly measured, the students testified that accessing the LMS services through the streamlined interfaces was fast and that it did not require much resources in terms of bandwidth requirements. On average, it was shown that login sessions for accessing Vula through mVula interfaces lasted 2 minutes, in which time, 2-3 services were accessed with various activities accomplished.

## **5.5 Summary**

The mLMS (mVula) interface was implemented and evaluated at the University of Cape Town. The application was evaluated for: (i) Ease-of-use, which was carried out using standard usability evaluation procedures for ease-of-use, complemented with case-specific measures. The goal for the usability evaluation was to verify the selected optimization approach of Vula, test for the feasibility of the mVula ideas and to gain feedback about the ease-of-use, perceived usefulness and, acceptance/satisfaction of the mVula. (ii) Impact, which was based on the Outcome Mapping approach. The impact evaluation was aimed at establishing the extent to which streamlined (tailored/directed) mobile interfaces (mVula application) for LMSs influence the students' behaviour/patterns in accessing LMS services. The evaluation results show that the students preferred the streamlined mVula interface to the full Vula mobile interface in accessing Vula on their mobile phones. This was evidenced by the increased use of mVula while the use of the full Vula mobile interface decreased during the last weeks of the evaluation period where the students were free to choose which application to use.

The results from the evaluation of mVula also indicated that the ideas presented in mVula are technically feasible and that the bulk of the mLMS application can be developed as cross platform, then platform specific functionality can be provided as accompanying applications, thus reducing the development effort. The application was found to be useful to the students and the students were encouraged to use their mobile phones to access Vula services more

often using their mobile phones. In turn, this would be expected to reduce the over-reliance and pressure on the constrained institutional ICT resources.

Overall, the application was intended to: enhance LMS accessibility on mobile phones; and encourage the students to use their mobile phones to access the LMS services. The purpose of the evaluation was therefore to assess whether the mVula application is usable and useful to the students and, leads to increased use of the LMS (Vula) by the students through their mobile phones. Indeed, the evaluation results indicated that enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces has an impact on the students' access behaviours/patterns of the LMS services. However it is yet to be proved that improved access is sufficient for a greater educational impact. It should therefore be noted that refactoring the LMS for mobile access may not necessarily address some of the issues regarding the effectiveness of LMSs in teaching and learning.

Further conclusions arising out of the evaluation results of mVula are presented in the next chapter (Chapter 6).



## **CHAPTER 6: SUMMARY, CONCLUSIONS, LIMITATIONS AND FUTURE DIRECTIONS**

### **6.1 Introduction**

This chapter presents the summary, conclusions and limitations of the study, as well as the suggestions for future work. The summary (Section 6.2) revisits the research problem, objective and the research questions, highlighting how each of the research questions was answered. Section 6.3 contains the conclusions arising from the study process as well as from the evaluation results of the intervention. These conclusions also highlight the contributions of this work. Section 6.4 is the limitations and Section 6.5 highlights the areas for future work.

### **6.2 Summary of the Study**

The problem addressed in this study was the limited success of LMS implementation in developing country universities, mainly due to ICT infrastructural constraints that limited the students' access to the LMS services. The main research question was: how can we better use the available ICTs and ICT infrastructure in developing country universities to enhance the accessibility of the LMS services by students and support the implementation of LMSs? With a high proliferation of mobile phones among the university students as had been revealed by the survey, the study explored and experimented with the integration of mobile phones into the LMS ecology so that the students could more easily access LMS services through their mobile phones. It was anticipated that, since the majority of students (in the surveyed universities) possessed Internet-enabled phones, careful integration of the mobile phones into the LMS ecology (which involved creation of usable mobile LMS interfaces) would allow the students to use their mobile phones to access the LMS services without much need for institutional ICT infrastructure such as the LANs and computers. After all, mobile phones are also less affected by other constraints such as electricity outages.

The study was guided by the following specific research questions:

- i. What is the current status of LMS implementation in developing country universities?
- ii. What services of the LMS are more needed and required by the learners in developing country universities?

- iii. How can we partition the services of an LMS for accessibility through mobile computing devices such as mobile phones?
- iv. Does enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces have any impact on the students' access behaviours/patterns of the LMS services?

These research questions were answered through surveys and experimentation. Two surveys were carried out, and the findings of these surveys were useful in understanding the current state of practice in LMS implementation in developing country universities, focusing the research problem, understanding the LMS needs of the students and deciding the nature of the intervention to be implemented. Specifically, the first survey revealed that LMS implementation in developing country universities is limited by a number of factors, most importantly the constrained ICT infrastructure (such as the lack of computers and computer laboratories; poor Internet connectivity and in some cases absence of LANs; limited and expensive Internet bandwidth; and electricity outages) that limited LMS access by the students. The findings of this survey, as described in Section 3.2 of Chapter 3 highlighted the current status of LMS implementation in the surveyed universities (which can be generalized for the majority developing country universities), thereby answering research question (i). The findings of the survey highlighted that, for LMSs to be more successfully implemented in the developing country universities, there is need to seek solutions to reduce the impact of such infrastructural constraints, either by improving the ICT infrastructure, or by seeking ways of using the available ICTs and ICT infrastructure to improve the students' access to the LMS services, notably enabling access of the LMS services through mobile phones.

In the second survey, which was carried to identify strategies of enabling better access to the LMS services by students in the developing country universities, it was revealed that, the majority of the students in the surveyed universities actually possessed mobile phones which they could use to access LMS services. However, the use of mobile phones to access LMS services was restricted by the available LMS interfaces that were not ideal for mobile access. The survey findings highlighted the need to design and develop streamlined mobile LMS interfaces to enhance the accessibility of the LMS through mobile phones. From the surveyed literature, it was revealed that the optimization of websites for mobile access can be done either by: enabling access to fewer services through the mobile phone, but with all the necessary detail for each service; or by enabling access to all the website services through the mobile phone, but with little detail for each service. In this case, given that LMSs have

several services some of which are occasionally (or not at all) used/accessed by the students, the most feasible and appropriate way to optimize the LMS for mobile access would be by providing access to a few selected services on the mobile phone. This therefore necessitated the need to identify the most required LMS services so that these are the one that are provided access for on the mobile phone. These services (which included announcements, assignments, resources, course outlines, chatrooms, and discussion forums) were identified through the second survey, thereby answering research question (ii).

Research questions (iii) and (iv) were answered through experimentation and evaluation. The experimentation involved the design, development, implementation and evaluation of the mobile Vula application. These processes were achieved through a UCD approach and HCI techniques. Specifically, mVula interfaces for accessing selected Vula services on the mobile phones were designed through paper prototyping with the students in a participatory design process. The paper prototype was then developed into a working mVula prototype. The mVula prototype included the eight top ranked most needed/required Vula services: announcements, assignments, resources, forums, chat rooms assignments, forums and groups. The application could as well have more or less services, but eight was considered an optimum number given the screen size limitation of the mobile phone.

Research question (iii) was therefore answered by the combination of the user focus groups (during the participatory design process) where the users selected the service-based interfaces (as opposed to course-based) for the mobile LMS interface, and the verification in the evaluation for ease-of-use and perceived usefulness that the service-based interfaces for the mLMS were acceptable.

Vula (Sakai), and indeed most of the current generation of LMSs, is modular and could be componentized. The partitioning of the LMS for mobile access through mobile Vula was achieved through the use of APIs via SOAP and REST endpoints. The client side of the mVula application was developed using JavaScript, HTML and CSS while the back end of the application was developed using PHP, linking to the Vula server via the SOAP and REST endpoints, and in cases where the REST points were inactive or not available, which was the case for most services, HTML was scraped from the existing Vula portal.

The developed mVula application was evaluated for ease-of use with HCI experts, through focus groups and through user experience evaluation and the application was improved after each evaluation using the obtained feedback. The final prototype was then evaluated for user

satisfaction and perceived usefulness and the overall impact through a longitudinal evaluation. The findings of the impact evaluation (which included students' self-reports and system user log data) were critically analysed to determine if the intervention produced the desired effects and to determine whether the observed effects could reasonably be attributed to the intervention. These provided the answer to research question (iv).

The findings indicated that the students' access behaviours of Vula services were influenced by the mVula intervention. The mobile Vula application was usable and satisfied most of the students' needs and desires for the mobile LMS. Actually, the mVula mobile interface encouraged greater access of Vula on the mobile phones and allowed students to get the information they needed without the need for a full desktop interface. The students used the mVula application more often than the other interfaces to access Vula services. Achieving this goal meant that the need for desktop or laptop computers (which are in short supply) to access the LMS services was reduced, and the extra cost of accessing the full LMS would be incurred relatively rarely. Further conclusions arising from the study are given in the next section.

### **6.3 Conclusions**

The limited success of LMS implementation in developing country universities is mainly due to the constrained ICT infrastructure and services in the institutions, which limits students' LMS accessibility. One way of improving the students' LMS accessibility is by integrating mobile phones into the LMS ecology.

As demonstrated in this study, the integration of mobile phones into the LMS ecology by designing and developing more usable (streamlined) mobile LMS interfaces was found to be effective in enhancing the accessibility of the LMS services by the students. The streamlined mobile LMS interface (the mVula application) was found useful and easier to use by the students to access Vula services on the mobile phones than the full Vula mobile interface. Students continue using the application even after the evaluation period.

The acceptability of the mVula application was also enhanced by the fact that the students were put at the centre of the design and development process of the application interfaces. The mVula interfaces were designed with students' involvement in a participatory design process (co-design). This further demonstrates the importance of putting the students at the centre of the design and development process of usable mobile LMS interfaces. Actually, as

demonstrated in this study, the co-design process of the mobile interfaces can be enhanced by providing the participants with familiar mobile phone screen templates (such as those shown in Figure 4.4), instead of plain paper. This is particularly important for participants who are not so familiar with mobile interface designs, like it was the case for the participants in this study.

This study also concludes that understanding students' expectations for a mobile LMS and involving the students in the design process of the mobile LMS interfaces is key to designing and developing usable and useful mobile interfaces for accessing LMS services, like was the case in this study. The evaluation results obtained in this study are evidence of the ease-of-use and usefulness of the mVula interfaces. From the design, implementation and evaluation processes of mVula, it has been demonstrated that mobile interfaces for LMSs can be made more usable and useful by selecting an appropriate subset of services. Furthermore, the students in the surveyed universities, and most likely in most of the developing country universities prefer:

- to go through less “clicks” before they can be able to access the desired LMS information;
- that LMSs should be componentized for access through mobile phones;
- that access of LMS through the mobile phones should be service-based, as opposed to course-based (as shown in Figure 4.11), and to have information (e.g. the announcements) merged from across courses;
- to have block-based interfaces for the services on initial login(as shown in Figure 4.11); and
- that the mobile LMS application should be made as simple as possible and non-crowded, that is, fewer LMS services (the most needed and desired services) should be made accessible through mobile phones.

All this was implemented and evaluated and achieved with the mobile Vula application. Thus, it can be concluded that with streamlined mobile LMS interfaces, such as mVula, the small mobile phone screens (and other mobile phone limitations) are less of a barrier for the students in accessing the LMS services through mobile phones.

Additionally, the study also concludes that most of the students' mobile LMS needs (particularly in the surveyed universities) can be achieved through a cross-platform mobile

Web application. As demonstrated by this study, the bulk of the mLMS application can be developed as cross-platform application, then platform-specific functionality can be provided as accompanying applications, thus reducing the development effort.

The process and results of this study and, more specifically, the mVula intervention indicate that careful integration of the mobile phones into the ecology of LMSs encourages the students in developing country universities to use their mobile phones to access the LMS services, thereby enhancing students' mobile learning.

Overall, the results of this study confirm that refactoring LMSs for multi-device use, specifically for mobile access, is key to more successfully implementing LMSs in developing country universities. The ongoing log data of the Vula LMS indicates that students at the University of Cape Town continue to use the mVula application.

In addition, it is also important to note that as opposed to the conventional interfaces such as those assumed by the current LMSs, the future design and architecture of LMSs should consider focused user interfaces or abstract models in a layered architecture in order to better match the type of the current generation of users. This is related to the trend towards instant gratification systems like twitter and other Web 2.0 systems, which have attracted user attention.

#### **6.4 Limitations of the Study**

As Mugwanya (2013) points out, when conducting scientific work, one must keep in mind the various aspects that validate the outcomes of research work, for example: the selection and validity of participant samples; the data collected; the repeatability of the study; and the generalisation of their results.

In the case of this study, although efforts were made to minimise bias in instances of participant selection (during the design and evaluation process), the validity of participant samples could still have been limited. Furthermore, impact studies such as this one require more time to generate more conclusive and generalisable results. It is therefore yet to be proved further that the observed improved access of the LMS services by the students as a result of the streamlined mobile LMS interfaces is sufficient for a greater educational impact.

The intervention (mobile LMS) was tested in one university– the University of Cape Town (UCT). The conclusions generated from the intervention may not necessarily be indicative of what the results of the intervention would be in the rest of the developing world universities. However, as a leading university on the continent, UCT is a good choice as other institutions typically try to copy what it does.

Like in the majority of design studies, the data collected in the initial surveys (requirements analysis) was mainly qualitative and contained some contradicting user requirements, some of which were actually over-ambitious. Some of the user requirements were not attended to or at most dropped simply because they were regarded as over-ambitious, unrealistic or unachievable within the resource and time limitations of the study.

Technically, the development of the mVula application was also complicated and to some extent limited by the lack of APIs.

## **6.5 Directions for Future Work**

This section identifies avenues for future research in this area.

### **6.5.1 Further Studies to Understand Students' Requirements for LMSs**

This study identified the need and importance of understanding how students would like to use learning management systems. Since almost every university uses an LMS of some sort, this study encourages the implementing universities to identify the LMS needs for their students. Furthermore, the LMS developers should devote more time and attention to understand the students' needs for the LMSs. More so, different institutions in different environments may use the LMSs differently and for different purposes.

### **6.5.2 Further evaluations to Assess the Viability of Mobile LMS**

The mobile LMS application (mVula) that was designed, developed and implemented in this study was also evaluated for usability as well as the impact that it had on the students' access behaviour of the LMS services.

The impact of mVula was evaluated through a longitudinal study in which the application was deployed for students' use for a period of six weeks. At the end of the sixth week,

evaluation data in the form of students' self-reports (through an online questionnaire) and Vula usage log data were obtained and analyzed.

As described in section 5.3 in Chapter 5, the mVula impact evaluation was aimed at answering research question (iv), which is: *“Does enabling access of some (student-selected) LMS services through streamlined mobile LMS interfaces have any impact on the students' access behaviours/patterns of the LMS services?”*

The results of both the students' self reports and the user logs indicated an increase in the students' access of the LMS services, more specifically through the mobile phones. The mVula application was found to be usable and useful to the students in accessing the LMS services through their mobile phones.

However, as already highlighted above, there is need for further studies to prove whether the observed improved access of the LMS services by the students through their mobile phones as a result of the streamlined mobile LMS interfaces brings about an educational impact.

This study has therefore set the stage from where more longitudinal evaluations and analysis of mLMS can be done. From these, more insightful observations could emerge. For example, as already stated, it would be important to investigate what pedagogical gains are made from using a mobile LMS?

### **6.5.3 Further Development Efforts**

In the development of the mVula application, jQuery did not allow much access to the device's native features as probably other development tools such as PhoneGap would do. Allowing access to the native features would allow for much richer user experiences, such as accessing the device storage, and more features could probably be built into the application to increase user satisfaction. This can be further investigated. Additionally, to further make the mobile LMS interface more appropriate for individual learners, the application could probably be improved (developed) in such a way to allow individual learners to customise the interfaces based on individual needs. In other words, can users compose what they want on mobile LMSs? It is increasingly likely that this is where mobile UIs are heading.

This study also encourages further research into the creation of an abstraction layer for LMS services. Although this has been done to some degree in the current Sakai version, it is not clear how well it works, and how do we evaluate it?



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## APPENDICES

Appendix 3.1: A semi-structured interview guide for the interviews with the key e-learning personalities in the universities

Thank you for accepting to participate in the Survey that is on the Success/Failure of learning Management systems in developing country Universities.

**KINDLY FILL THIS *page* AND SEND BACK TO ME TO SCHEDULE AN INTERVIEW WITH YOU. USE QUESTIONS ON THE NEXT PAGE ARE TO PREPARE FOR THE INTERVIEW**

### ***Institution, Position and Responsibilities of Respondent***

Name of Institution .....

Name of Respondent:.....

PositionHeld .....

Length of Service of Respondent in e-Learning Related projects at the University.....

What would you say is the most important part of your job related to e-learning in your Institution?.....

---

### ***Interview Schedule***

When are you Available for a Skype/Telephone call? (May give more than one time options)

*Either,*

DATE:.....TIME:.....

*Or*

DATE:..... TIME:.....

Respondent's Skype ID:.....

Telephone No (including country code).....

How would you prefer us to contact you for the interview? Telephone or Skype? (We would prefer Skyping if it is possible with you.)

.....

**These Questions will guide the Interview**

- 1) **What e-learning Initiatives has your institution been involved in the last decade? How were they initiated?** Was there:
  - i. A needs assessment to determine if the initiatives were a "must have" or a "nice to have"
  - ii. A requirements analysis to document and understand internal stakeholder needs
  - iii. A strategic plan that documents specific objectives and goals and how they align with institutional goals?
- 2) **What Learning Management Systems (LMS) has your institution used in past? And which one are you using now?**
  - i. Who decides which tools/platforms to use in your institution?
- 3) **How did you arrive at the decision to choose that particular platform?** Was there:
  - i. User research to determine to what extent staff welcome and will use LMS?
  - ii. A feasibility study to determine the potential barriers to success and whether the LMS can be implemented in a reasonable time, at a reasonable cost?
  - iii. A communication plan on how the institution will market the LMS to ensure use?
  - iv. A business case proving the cost benefit analysis?
  - v. A measurement plan detailing the critical success factors and performance measures (e.g., use, ROI, etc.)
- 4) **What did you expect the LMS to do for you/ what problems did you expect it to help you overcome?**
- 5) **To what extent has the LMS met the expectations mentioned in (4) above?**
- 6) **According to your own assessment;**
  - i. Do teachers in your institution have an appetite to use the LMS? (briefly explain)
  - ii. Do students in your institution have an appetite to learn using the LMS? (briefly explain)
- 7) **Any specific problems you have identified with the LMS that have caused setback to the implementation of e-learning in your institution?**
  - i. If you were to change two things on the LMS, what would they be?
- 8) **How would you rate the success of the current LMS implementation?** (Very Successful; Successful; Minimal Success; un successful; Hard to Tell) – Explain
- 9) **How do you assess success and meeting expectations?**
- 10) **What factors have limited the success of LMS implementation in your university?**
- 11) **How will you monitor deployment going forward?**



## Appendix 3.2: Ethical clearance for the students' survey

Department of Environmental and Geographical Science  
University of Cape Town  
RONDEBOSCH 7701  
South Africa

e-mail: Michael.meadows@uct.ac.za  
phone : + 27 21 650 2873  
fax : +27 21 650 3791



1<sup>st</sup> September 2011

Ms G Ssekakubo  
Department of Computer Science  
University of Cape Town

Dear Ms Ssekakubo

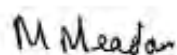
### **Refactoring Learning Management Systems for Multi-Device Use in Developing Countries**

I am pleased to inform you that, having scrutinized the details of your above-named application for research ethics clearance, the Faculty of Science Research Ethics Committee has approved it in terms of its attention to ethical principles.

Your approval code is: SFREC 023\_2011

I wish you success in the work involved.

Yours sincerely



Michael E Meadows  
Professor and Head of Department  
Chair: Science Faculty Ethics in Research Committee

### Appendix 3.3: Electronic survey questionnaire on students' expectations and experiences with LMSs



## LMS Services, Usage and Accessibility

University of Cape Town  
Department of Computer Science  
ICT4D Research Centre  
Grace Ssekakubo (grace.ssekakubo@uct.ac.za)

### Questionnaire

Dear Respondent,

We want to find out how learners in developing countries access the services of learning management systems (LMSs), and what services of the LMS are they (the learners) more interested in.

The information and views that you give us will contribute to our insight into the best way to deploy LMSs to better support learners in developing countries and to develop more effective ways of providing the services of LMSs.

- Please answer all the questions honestly and don't skip any
- In questions with ☐ can tick several answers
- In questions with ☐ please tick one, row-wise
- There are no "Right" or "Wrong Answers"
- NOTE: Vula and Moodle are Learning Management Systems

1. Which is the main domain of study of your degree?	
Science and Technology (e.g. Engineering, Maths, computing, Biology, Chemistry)	<input type="radio"/>
Humanities and Social sciences(e.g. Arts, History, Language, Media, politics, psychology)	<input type="radio"/>
Business and Management	<input type="radio"/>
Law	<input type="radio"/>
Health Sciences	<input type="radio"/>

	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
2. What is your year of study?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	yes	no
3. Do you own a mobile phone?	<input type="radio"/>	<input type="radio"/>
↳ If yes, Is your mobile phone a smart phone? i.e. can you access internet on it?	<input type="radio"/>	<input type="radio"/>

	Vula	Moodle
4. Which learning management system do you use?	<input type="radio"/>	<input type="radio"/>

5. How often do you access Vula/Moodle?						
several times daily	about once a day	3-5 days a week	1-2 days a week	every few weeks	less often	never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. When you access Vula/Moodle, how often do you do so...					
	All the time	Most of the time	Some of the time	Occasionally	never
on a computer/laptop at the university	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
on a computer/laptop at home	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
on a mobile phone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In an internet cafe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Where else do you access Vula/Moodle?					
_____					

7. If the following devices for accessing Vula/Moodle were available to you, which one would you prefer to use? And why?

computer/laptop	<input type="radio"/>
mobile phone	<input type="radio"/>
Other:	<input type="radio"/>
Why? _____ _____	

8. To what extent do you agree that the following services of Vula/Moodle are very important?

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<b>Announcements</b>	For viewing current, time critical information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Assignments</b>	For posting and submitting assignments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Blogs</b>	For course or project blogging or journals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Calendar</b>	For viewing deadlines, events, etc	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Chat Room</b>	For real-time conversations in written form	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Course Outline</b>	For summary outline and/or course requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Drop Box</b>	For private file sharing between instructor and student	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Email Archive</b>	For viewing e-mails sent to the site	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Forums</b>	Display forums and topics of the course					
<b>Maps</b>	For using interactive Google Maps	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Messages</b>	Display messages to/from course participants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>News</b>	For displaying news and updates from online sources (RSS feeds)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Participants</b>	For viewing course participant list	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Podcasts</b>	For managing individual podcasts and podcasts feed information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Polls</b>	For anonymous polls or voting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Q&amp;A</b>	For asking and answering questions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Resources</b>	For accessing documents, URLs or other websites	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Search</b>	For searching content within course or across courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Slideshow</b>	For showing and viewing slideshows of image collections from resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Tests &amp; Quizzes</b>	For taking online tests/quizzes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
What other service of vula/Moodle is important?: _____						

9. Which services of Vula/Moodle are you required to use most often?

Announcements	<input type="checkbox"/>	News	<input type="checkbox"/>
Assignments	<input type="checkbox"/>	Participants	<input type="checkbox"/>
Blogs	<input type="checkbox"/>	Podcasts	<input type="checkbox"/>
Calendar	<input type="checkbox"/>	Polls	<input type="checkbox"/>
Course Outline	<input type="checkbox"/>	Q&A	<input type="checkbox"/>
Drop Box	<input type="checkbox"/>	Resources	<input type="checkbox"/>
Email Archive	<input type="checkbox"/>	Search	<input type="checkbox"/>
Forums	<input type="checkbox"/>	Slides	<input type="checkbox"/>
Maps	<input type="checkbox"/>	Tests & Quizzes	<input type="checkbox"/>
Messages	<input type="checkbox"/>	Wiki	<input type="checkbox"/>
Other: _____			<input type="checkbox"/>

10. Which services of vula/Moodle would you like to access more frequently (including in class, if possible)?

Announcements	<input type="checkbox"/>	News	<input type="checkbox"/>
Assignments	<input type="checkbox"/>	Participants	<input type="checkbox"/>
Blogs	<input type="checkbox"/>	Podcasts	<input type="checkbox"/>
Calendar	<input type="checkbox"/>	Polls	<input type="checkbox"/>
Course Outline	<input type="checkbox"/>	Q&A	<input type="checkbox"/>
Drop Box	<input type="checkbox"/>	Resources	<input type="checkbox"/>
Email Archive	<input type="checkbox"/>	Search	<input type="checkbox"/>
Forums	<input type="checkbox"/>	Slides	<input type="checkbox"/>
Maps	<input type="checkbox"/>	Tests & Quizzes	<input type="checkbox"/>
Messages	<input type="checkbox"/>	Wiki	<input type="checkbox"/>
Other: _____			<input type="checkbox"/>

Please share with any other thing you feel about Vula/Moodle or your experience with Learning Management Systems

**THANK YOU VERY MUCH!**

## Appendix 5.1: Electronic questionnaire for the 1st user experience evaluation (Usability evaluation) of mobile Vula

### Questionnaire for the 1<sup>st</sup> User Experience (Usability) Evaluation of mVula

Dear Respondent,

Thank you for taking the time to participate in our evaluation of mVula WepApp. In mVula, we implemented some of the ideals aimed at effective and satisfactory optimisation of a learning management system for mobile access. Having used mVula, we believe that you are in good position to evaluate the ideas presented in the application, and the application itself—in terms of its ease of use and perceived usefulness in accessing some of the Vula services on the mobile phone.

You are thus requested to participate in this evaluation survey by answering the following short questions. Please note that, participation is optional and anonymous.

***In this section, indicate the extent to which you agree with the statement.***

1. Interaction with mVula is clear and understandable					
Strongly Agree	Agree	Neutral	Disagree	Strongly Agree	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

2. The applications is:					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Agree
Easy to use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Navigable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Intuitive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attractive to use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. If find it useful to use my mobile phone to access some services of Vula					
Strongly Agree	Agree	Neutral	Disagree	Strongly Agree	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

4. The following mVula features make it easier to access Vula via a mobile phone					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Agree
Having only a few options/services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using block-based interfaces for the services on initial login	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Merging information from across courses (e.g. announcements)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. mVula influences me to access Vula more often

Strongly					Strongly
Agree	Agree	Neutral	Disagree		Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>

6. mVula enhances my learning effectiveness:

	Strongly				Strongly
	Agree	Agree	Neutral	Disagree	Agree
In class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outside class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. mVula saves me the need for a computer all the time I need to access information on Vula

Strongly				Strongly
Agree	Agree	Neutral	Disagree	Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Overall Satisfaction

8. What is your overall satisfaction with the ideas presented in mVula

Highly		Partially	Not	Not at all
Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Narrative Section

9. Other than the services presented in mVula, which other services of Vula are you required to access more often?

.....

10. Why wouldn't you use mVula?

11. What features would you like to be added to mVula to enhance its usefulness to you?

12. Please share with us any other thing you feel about the ideas presented in mVula, and the Application itself.

**THANK YOU VERY MUCH**



## Appendix 5.2: Consent Form

### Consent Form

#### *Refactoring LMSs for Multi-Device Use*

You are invited to participate in the evaluation of mobile Vula (mVula) application. mVula application has been created to offer an alternate way of accessing selected services of Vula on the mobile phones.

You will be requested to use the application for a period of 4-5 weeks and thereafter you will be requested to assess its usefulness through a questionnaire that will be sent to you online. During the evaluation process, your use of Vula/mVula will be monitored to capture data about: frequency of access; device(s) used; services accessed. This data will ONLY be used (anonymously) for purposes of this research, to establish if there are any identifiable usage patterns of Vula attributable to the mVula Intervention.

Your signature below means that you voluntarily agree to participate in this evaluation process.

Student Number:..... e-mail address..... Sign.....

Grace Ssekakubo (Principal Investigator).....

*NB: Participation in this research project is completely voluntary. You have the right to say no, or change your mind at any time and withdraw. Participants will be given a participation incentive of R 30*

## Appendix 5.3: Electronic questionnaire for the 2nd user experience evaluation (Usability and Impact evaluation) of mobile Vula

### Questionnaire for the 2<sup>nd</sup> User Experience (Usability and Impact) Evaluation of mVula

Dear Respondent,

You are requested to evaluate the mVula application by answering the following short questions. Please note that, participation is optional and anonymous.

#### Choose the most correct alternative

1. On average, how often do you access Vula?					
several times daily	about once a day	3-5 days a week	1-2 days a week	every few weeks	never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. When you access Vula, how often do you do so...					
	All the time	Most of the time	Some of the time	Occasionally	never
Using your mobile phone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using the a computer/laptop	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using a tablet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. When you use your mobile phone to access Vula, how often do you do so...					
	All the time	Most of the time	Some of the time	Occasionally	never
ThroughmVula	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Throughthefull web interface	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Through other application (s)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Please mention the other application(s): .....					

4. When you use mVula, how often do you do so using the following devices:					
	All the time	Most of the time	Some of the time	Occasionally	never
Mobile phone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tablet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Laptop/PC	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

***In this section, indicate the extent to which you agree with the statement.***

5. Even without mVula I still use my phone to access Vula through the full web interface				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. With mVula, I am encouraged/influenced to access Vula more often				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. mVula saves me the need for a computer when I need to access information on Vula				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. mVula enhances my learning effectiveness:					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
In class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outside class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

		yes	no
9. Have you used the mVula notification feature?		<input type="radio"/>	<input type="radio"/>
↩ If yes, What is your view about it? .....			

10. mVula is sufficient without the notification (alerts) feature				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. To what extent do you agree that the following mVula features make it easier to access Vula services via mobile phones?					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Service- based, as opposed to being Course-based	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Having only a few services of Vula (the most needed/required)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using block-based interfaces for the services on initial login	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Merging information from across courses (e.g. announcements)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The notification service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Overall Satisfaction

12. What is your overall satisfaction with the mVula application?				
Highly Satisfied	Satisfied	Partially Satisfied	Not Satisfied	Not at all Satisfied
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Narrative Section

13. Please share with us any other thing you feel about the ideas presented in mVula, and the application itself.
---

**THANK YOU**